

**THE NEW CLOSE AIR SUPPORT WEAPON: UNMANNED COMBAT AERIAL VEHICLE  
IN 2010 AND BEYOND**

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Military History

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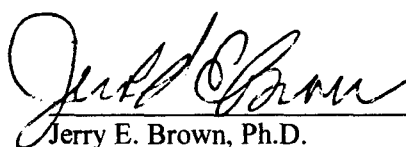
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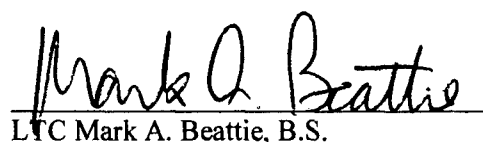
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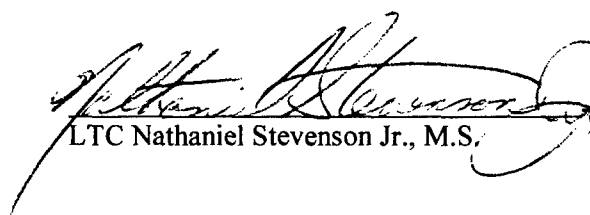
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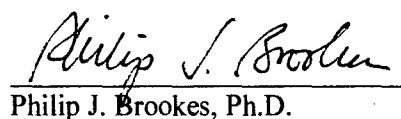
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## ABSTRACT

THE NEW CLOSE AIR SUPPORT WEAPON: UNMANNED COMBAT AERIAL VEHICLE  
IN 2010 AND BEYOND by MAJ Sharon L. Holmes, USAF, 92 pages.

This study investigates the viability of employing unmanned aerial vehicles in the close air support role on the future battlefield of 2010 and beyond. The concept of employing unmanned aerial vehicles in a strike role is currently in the advanced technology demonstration phase of design. Budgetary constraints, aircraft shortfalls, and theater commander-in-chief (CINC) requirements have combined to form an impetus for accelerated research in unmanned aircraft capabilities, and refocused DoD on fiscally conservative methods to ensure national defense and equip military forces for war.

This study evaluates the historical and doctrinal underpinnings of unmanned aerial vehicles and the close air support infrastructure to establish a basis for compatibility. Enhanced UAV technology and accelerated information technology advances combine to form an information architecture robust enough to handle unmanned aircraft in a strike role. Future employment of UAVs in a strike role is possible technologically by 2010, however doctrine and military will lag while USAF leaders grapple with the proper unmanned-manned force.

The unmanned combat aerial vehicle (UCAV) technology, time critical targeting infrastructure, and refined joint doctrine combined synergistically with military will offer the theater CINC one more combat multiplier. Prudent strategic planning for research, design, development and employment of unmanned aerial vehicles will keep the U.S. military prepared to fight any conflict, any time, any place.

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## LIST OF ABBREVIATIONS

AAA	Anti-aircraft Artillery
ABCCC	Airborne Battlefield Command and Control Center
ACA	Airspace Control Authority
ACC	Air Combat Command
ACSC	Air Command and Staff College
ACTD	Advanced Concept Technology Demonstration
ADR	Annual Defense Review
AGM	Air Guided Missile
ASOC	Air Support Operations Center
ATD	Advanced Technology Demonstration
AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
BLACS	Barometric Low Altitude Control System
BPI	Ballistic Missile Position Indicator
C2	Command and Control
CAS	Close Air Support
CBU	Cluster Bomb Unit
CINC	Commander-in-Chief
COMINT	Communications Intelligence
CONUS	Continental United States
CRC	Control and Reporting Center
CTC	Combat Training Center
DARPA	DoD Advanced Research Projects Agency
DCO	Direct Control Operators



DMZ	Demilitarized Zone
ECM	Electronic Counter Measures
ELINT	Electronic Intelligence
EO	Electro-optical
FAA	Federal Aviation Administration
FEAF	Far East Air Forces
FLIR	Forward-Looking Infrared
FLOT	Forward Line of Troops
FSCL	Fire Support Coordination Line
FY	Fiscal Year
GB	Glide Bomb
GP	General Purpose (bomb)
GPS	Global Positioning System
HAE	High-Altitude Endurance
HEI	High Explosive Incendiary
IR	Infrared
IRST	Infrared Seeker and Kinetic Kill Thruster
ISR	Intelligence, Surveillance and Reconnaissance
JAOC	Joint Air Operations Center
JATO	Jet Assisted Take Off
JCAS	Joint Close Air Support
JFACC	Joint Forces Air Component Commander
JFC	Joint Forces Commander
JP	Joint Publication
JROC	Joint Requirements Oversight Council

JSF	Joint Strike Fighter
JSTARS	Joint Surveillance and Targeting Acquisition Radar System
JT&E	Joint Test & Evaluation
JV	Joint Vision
KTO	Kuwaiti Theater of Operations
LGB	Laser Guided Bomb
LOCAAS	Low Cost Autonomous Attack System
LOS	Line of Sight
LTD	Laser Target Designator
MAGTF	Marine Air-Ground Task Force
MARS	Mid-air Retrieval System
MICOM	Missile Command (Army)
MOOTW	Military Operations Other Than War
MTW	Major Theater War
NAS	National Airspace System
NATO	North Atlantic Treaty Organization
NBC	Nuclear, Biological and Chemical
NVG	Night Vision Goggles
OODA	Observation-Oriented-Decision-Action (Loop)
OSD	Office of the Secretary of Defense
OTH	Over-the-Horizon Targeting
PTA	Pilotless Target Aircraft
R & D	Research and Development
RALACS	Radar Altimeter Low Altitude Control System
RCO	Remote Control Officer

RPV	Remotely Piloted Vehicles
RSTA	Reconnaissance, Surveillance, Targeting Acquisition
SAB	Science Advisory Board
SAC	Strategic Air Command
SAM	Surface to Air Missile
SAR	Synthetic Aperture Radar
SEAD	Suppression of Enemy Air Defenses
SOF	Special Operations Forces
SRW	Strategic Reconnaissance Wing
TAC	Tactical Air Command
TACP	Tactical Air Control Party
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UN	United Nations
WP	White phosphorous (rocket)

## CHAPTER 1

### THE NEW CLOSE AIR SUPPORT WEAPON—UNMANNED COMBAT AERIAL VEHICLES IN 2010 AND BEYOND

Only when the enemy could not be overcome by moral strength and intellectual faculty of man was there recourse to armed force, which was applied so that victory was gained: in the shortest possible time, at the least possible cost in lives and effort, and with the fewest possible casualties. (Sun Tzu, 500 B.C., 39)

In order to evaluate the viability of unmanned aerial vehicles (UAVs) in a close air support (CAS) role, doctrine, military necessity, technology and military will must merge into a cohesive, coordinated effort. The historical framework for UAV development and employment in military operations establishes the foundation for UAV viability on today's battlefield. But, where does the military apply the historical lessons learned from periods of rapidly accelerated UAV design during national emergencies? The researcher suggests the United States until the 1990s failed to advance plan integration of unmanned systems into combat operations until military operations or the political climate forced the military will to deliver a quick fix. Fiscal constraints and uncertain future adversaries demand prudent, cohesive modernization and overarching, long-term planning to meet unknown challenges. Developing UAVs as weapons carriers could potentially thwart the efforts of future adversaries in a highly complementary role that enhances aerospace employment worldwide.

Balancing the need to modernize with the accelerating costs of modernization often creates gaps in capability or limited quantities of new equipment, which are crucial to maintaining a relevant military machine. Additionally, targeted modernization across the full spectrum of warfighting capabilities is key to ending up on the victor's side versus the loser's bracket in a Revolution in Military Affairs. *Joint Vision 2010* challenges today's leaders to make hard choices to achieve the tradeoffs that will bring the best balance, most capability, and greatest interoperability for the least cost (1996, 13). Military leaders today must take calculated risks,

avoid mortgaging the nation's future, and seek new lower-cost technologies capable of targeting enemy forces.

The focus for the Joint Chiefs and the Service Components are information systems, space-based systems and high-altitude, endurance reconnaissance platforms which affect the strategic level of warfare. Where the joint team meets and fights as a Joint Task Force or Multinational Force, CAS becomes an issue due to the competing requirements for multirole fighter aircraft to maintain air superiority and support ground commanders in contact with enemy forces. Desert Storm highlighted the importance of improving weapons that affect the strategic level of warfare, but also pointed to the need to develop weapons which conquer the enemy force at the tactical and operational levels of warfare. The attack on Al Khafji, twelve days into the air war, served notice that the exceptional air security net was not a 100 percent deterrent to Iraqi offensive ground operations. Superior ground forces and well-timed CAS by A-10s and AC-130s destroyed a mechanized infantry division and elements of three armored/mechanized divisions retreating from Al Khafji (Mann, 1995,132). Once the independent air campaign ceased, the ground campaign commenced to accomplish one of the key stated goals of Desert Storm: removal of Iraqi forces from Kuwait and destruction of one of the Iraqi centers of gravity--the Republican Guard. The quest to minimize American casualties and accelerate the decisive victory demanded airpower, specifically CAS assets.

During Operation Desert Storm, U.S. air assets alone were adequate to accomplish the strategic and operational level fight waged over Iraq. Today's U.S. military machine pales in comparison to the 1991 force. In the 1997 *Quadrennial Defense Review*, the total Army stood at the smallest level in fifty-eight years and anticipated further decreases. "From 1989 to 1997, the Total Army reduced its ranks by 630,000 soldiers and civilians. The Army reduced its divisions, active and reserve, from 28 to 18 and has shifted from a forward deployed force to a primarily Continental United States (CONUS)-based force" (Walker and Reimer, 1998,4). The Air Force

has been reduced to twenty general purpose fighter wing equivalents since 1989 and is currently undergoing a massive military retention problem. Military personnel retention is at an all-time low for all the services. The worldwide deployments continue to rise each year, but the bodies may not be sufficient to field every combat unit required. Some weapon system must fill this military personnel gap. Perhaps, UAVs can augment a sparse force in the CAS role.

The UAVs are receiving steady emphasis from the Joint Chiefs and most of the services. Expanded roles and missions study for UAVs must strike while the money and interest are flowing. UAV development has fallen in and out of favor based on political and military necessity since World War II. Pilotless aircraft have demonstrated their worth in the reconnaissance and electronic intelligence (ELINT) environment throughout the UAV's rocky history. In fact, today's tactical aviators do not see UAVs as threatening to piloted flight, but more of a combat force multiplier. Additionally, increased mobility of land forces has made land component commanders more reliant on airpower, not merely as a maneuver element, but as a decisive weapon in the close fight. UAV design and production as a CAS platform can increase availability of CAS platforms for joint forces.

Faced with these fiscal and personnel challenges, this study concentrates on assessing the viability of UAVs in a CAS role. The capabilities of UAVs and the CAS system architecture along with joint CAS doctrine will serve as the framework for evaluating the potential of current UAV technologies to execute the CAS mission. Although the various services have distinct perspectives on CAS, this study focuses on the areas where the services act from a common reference point. The study will remain in the unclassified domain and avoid recommending specific weaponry to equip the UAVs, rather seeking to evaluate overall capability and command infrastructure of emerging UAV technologies. More UAVs designed specifically for ground attack will effectively meet a military mission need and free up dollars and pilots to research and develop strategic weapons and pilot other inhabited airframes.

## Methodology

Chapter 2 traces the historical underpinnings of UAV design, adaptation in warfare and modification in peacetime. The technological advantages, sensor improvements and system architecture improvements serve as a benchmark to evaluate current-day UAV platforms.

Chapter 3 evaluates the entire CAS infrastructure from the historical underpinnings, to doctrinal requirements, through system capabilities and future requirements. First, the researcher will examine closely the historical record on the use and misuse of CAS and any sustaining imperatives or essentials for CAS systems. The central question in each historical vignette involves what happened, what was the environment, and what was the essential CAS lesson? This brief historical view will identify the CAS essentials which form the basis for the criteria which UAVs must fulfill in the CAS role. Next, the focus shifts to a look at Joint CAS doctrine and a refinement of the CAS essentials. Joint CAS doctrine serves as the doctrinal measuring stick to evaluate whether the UAV infrastructure and command and control system is adequate to use unmanned systems for CAS. Then, the researcher takes a brief snapshot of some of the major manned platforms conducting CAS and their accompanying capabilities, modernization schedule and gaps in capability. The review of current manned CAS platform modernization and gaps serves to establish the military necessity of alternative CAS platforms. Finally, the researcher will examine the Air Force, Army, and Joint vision of the future (FY2025) battlefield and the requirements to win the close fight. These consolidated vision statements regarding the future battlefield will highlight the focus for evaluating the emerging technology in unmanned systems and weapons which might elevate the UAV to a viable alternative for the CAS role.

In chapter 4, the researcher will examine the existing Joint UAV Doctrine in order to assess adaptability to embrace unmanned weapon carriers within the current doctrinal framework. This doctrinal review evaluates the suitability of the doctrine to effectively integrate unmanned systems in combat operations. Next, the research will shift to a look at the Air Force 2025

StrikeStar UAV Study detailing the necessity for and required capabilities of unmanned systems in the future battlefield. The role attributed by the Air Force to the UAV will serve as a platform to evaluate the technology required to bridge the gap in current day technology and future applications. Then, the research will focus on the uninhabited combat aerial vehicle (UCAV) currently under bid for contract as an Advanced Technology Demonstration platform. Emerging weapons, sensor, and UCAV technology and infrastructure will serve as the basis to evaluate the ability of unmanned systems to execute the close air support mission.

In chapter 5, the researcher will merge the CAS & UAV doctrinal requirements to determine if any doctrinal disconnects preclude an unmanned system from conducting the close air support role. Merging the doctrinal requirements will highlight gaps for future development or solidify the unmanned aerial vehicle's viability to conduct combat operations. Next, the researcher will examine the compatibility and incompatibility of UAV platforms or emerging UAV technology to meet the demands or essentials of the CAS mission. Finally, the researcher will highlight some current military leadership views on the use of UAVs as a strike platform or weapons carrier in future warfare to infer the climate for military will to employ unmanned systems as CAS platforms.

In chapter 6, the researcher will summarize the doctrinal, technological, and visionary framework for CAS and UAVs in the *Joint Vision 2010* and subsequent years of warfighting. Finally, the researcher will suggest a point of departure for future study on UAVs in a CAS role.

The following assumptions were made to focus and limit the scope of this research. The DoD focus on UAV research and development signals a greater acceptance of unmanned systems within the theater. The implementation of Science Advisory Board (SAB) UAV recommendations by the USAF indicates official support for the UAV research and development (R&D) plan and potential employment as a lethal weapon system. The current joint CAS doctrine is adequate to embrace any new weapon system, including unmanned aircraft.



Much of the research on the specific weapons and sensor systems on current UAVs remain in the classified, government domain. Therefore, the study focuses on UAVs currently under review and on their adaptability to the CAS role. The study evaluates UAVs from the joint doctrine perspective in the close fight instead of air interdiction and, extrapolates their potential for merging the CAS mission with the UAV system. Additionally, detailed lethal UAV adaptability data and airframe life cycle data remain in the classified domain. The research relies heavily on electronic mediums, published research reports, and telephone interviews.

Researching the viability of exploiting existing and emerging UAV technology as a CAS weapon system could offer a lower-cost method to bridge gaps in capability caused by personnel shortfalls and shrinking military procurement budgets. Offering an alternative to over ten years of research and development and budget wars, the UCAV will exploit *JV 2010* technology and command and control (C2) infrastructures; adapting the weapon systems to fit the mission. With the explosion of systems to link the battlefield in the joint fight, UAVs in a CAS role offer the Joint Force Commander and subordinate commanders one more joint force multiplier.

## CHAPTER 2

### HISTORY OF UAVs

Major General Ken Israel, Director US DARO warns, we need to back up a bit and see what we have (in UAV technology)... You can't defeat the enemy with R & D projects (Tirpak, 1997, 70).

But they that wait upon the Lord shall renew their strength; they shall mount up with wings as eagles; they shall run, and not be weary; and they shall walk, and not faint (Holy Bible, Isaiah 40:31).

Humankind has remained fascinated with flight since time immemorial. There has always been that quest, especially in warfare to fly higher, faster, maneuver better. Then a shift to low level flight operations occurred to defeat antiaircraft weapons. Now that the collective minds have conquered much of the atmospheric realm and technology has allowed faster, higher endurance flights; there is the quest for space-based assets and unmanned aircraft to bring an edge in warfare. In spite of the grab for more and more technology and the biggest, best toys on the battle field, the U.S. is engaged around the world in more smaller, lower-tech regional conflicts. Recent conflicts in the Middle East, Somalia and Bosnia have highlighted the continuing need for low to medium altitude airborne assets to enhance ground and sea-based maneuver forces. Space based assets are not totally adequate for the tactical and operational level fight.

Aviators are seriously evaluating uninhabited aerial vehicles as a combat force multiplier for enemy destruction. Technological research and development has shifted to uninhabited aerial vehicles in light of the horror and ugliness of downed aviators paraded around as prizes by their enemy captors. The political and, as a result, military will are adamant about denying hostile governments the opportunity to use aviators as political pawns. Through this brief review of UAV development, employment and progress perhaps a clearer picture of capabilities for future integration of these pilotless aircraft in FY 2010 and later conflicts will emerge.

The United States capitalizes on most technological opportunities supporting national security with an equal eye weighted on protecting economic interests. Maintaining this careful

balance in military and fiscal policy, the U.S. emphasis on UAVs have waxed and waned throughout our history. What are the historical roots of UAVs and is the evolution in technology sufficient to warrant the renewed focus on these pilotless vehicles as ground attack platforms?

### Definitions

First, some definitions of various types of uninhabited aerial vehicles (UAVs) are in order.

Uninhabited (unmanned) aerial vehicle (UAV): An aerial vehicle that has no onboard pilot and is capable of preprogrammed autonomous operation or operations received from a human operator located some distance (either on the ground or on a seaborne or airborne platform) from the vehicle.

Remotely piloted vehicle (RPV): Usually considered a subset of UAVs, RPVs are aerial vehicles that do not have an onboard pilot and are capable of receiving continuous or intermittent commands from a human operator located at a ground, seaborne, or airborne station some distance from the vehicle.

Drone: An aerial vehicle that has no onboard pilot and is preprogrammed prior to launch to accomplish a set of functions with no further human intervention or command. The drone may use onboard sensors to autonomously make mission adjustments. Drones are usually designed for such uses as expendable targets with relatively short operating distances and loiter times (Renehan, 1997, 5).

The simplest method to distinguish drones from RPVs and UAVs are their function as targets.

Remotely piloted vehicles normally require relay stations and operate in relatively close proximity to the human controller. Although there are fail safes integrated into the RPV platform for communication loss, the onboard system is not robust enough to integrate data and accomplish all military objectives without interim commands from the controller. RPVs are dependent on the ground or airborne controller for operations. The UAV platform is normally capable of extended operations outside line of sight communication of the controller due to the enhanced onboard data management system and satellite connectivity. UAVs process large volumes of data, defend against electronic countermeasures (ECM) threats and transmit information to military leaders almost instantaneously, thus serving as a more independent system. Despite these differences, some researchers and UAV supporters use UAV and RPV

interchangeably, therefore in this study the proper term has been substituted when deemed appropriate for clarity. With these distinctions in mind, the design and progress of pilotless aircraft from World War II through the 1990s unfolds.

## World War II

The first recorded use of an uninhabited aircraft as an instrument of destruction was “the German V1 missile and V2 rockets against London in World War II, and the Allies experimenting with aircraft packed with high explosives and crudely controlled towards their targets by radio (Reed, 1979, 5).” The V1, German revenge weapon carried one ton of high explosives and a robotic pilot, attained a maximum speed of 360 mph and delivered around 25 percent of its bombs on targets in Britain and Belgium (Lee, 1955, 58).

On 16 June 1944, ten days after the Normandy Invasion, Germany launched 244 V1 missiles at England. A total of 144 V1 missiles crossed the English Coast with 73 impacting the London area merely 22 minutes after launch (Armitage, 1988, 10). With the reign of missiles and bomber attacks on London, the Allies retaliated with strikes on the V1 ground launching sites forcing Germany to move the sites away from the coast. In July 1944, the German Luftwaffe designed the air-launched V1 missile to counter the threat to ground launching sites.

Technological improvements in navigation, extended range and radio emitters allowed these air-launched V1s to continue their reign of terror over Great Britain for seven months. During this seven month offensive, 2,419 of 8,892 V1 missiles reached the London region killing 7,810, injuring 17,981 and interrupting work in 30,000 factories as compared with 51,509 killed and 61,423 injured by conventional bombing in the United Kingdom during the whole war (Armitage, 1988, 16). Their small size, great speed, and dispersed launch sites greatly enhanced the effectiveness of this new pilotless weapon. The V1 missile tested the technical skill and ingenuity of the Allies in developing a responsive air defense system and proper tactics to thwart the German V1.

The Germans upped the ante through the fielding of the German V2 rocket. The capable V2 rocket carried one ton of high explosives, burned 8.5 tons of expensive liquid oxygen and alcohol, traveled 300 miles at over 3,500 mph and struck 40 percent of its targets (Lee, 1955, 58). Fortunately the V2 rocket proved extremely expensive to maintain because the Allies were unable to counter this weapon.

The United States attempted to enter the pilotless aircraft arena to stave off the massive loss of pilots to the strategic bombing campaigns. Initial efforts to field an unmanned aircraft included the GB-1 glide-bomb which consisted of a 2,000 pound general purpose bomb fitted with twelve foot wings, fins, a tailplane and an autopilot (Armitage, 1988, 24). The Army Air Corps VB-1 Azon Glide Bomb was used to strike railroads and bridges in Italy and the Burma Theater while in September 1944, combat missions were flown out of England with a television-radio controlled glide bomb against Germany (Wagner and Sloan, 1992, 15). Although these glide bombs proved mostly inaccurate and vulnerable to German ground fire, the U.S. developed better control mechanisms ranging from TV-guided, to radio and finally an active-homing radar guidance system.

A true unmanned aircraft program developed by the U.S. was the Aphrodite aircraft. The Aphrodite program reconfigured B-17 aircraft with open cockpits, radio-control devices and 20,000 pounds of explosives. The Aphrodite aircraft was designed to fly by radio control to a point short of the target where the pilot primed the fuse and baled out over the English coast, leaving the unmanned aircraft to continue to the target (Armitage, 1988, 31). A series of crashes and poor targeting canceled the Aphrodite program. The U.S. as an emerging world power, formed a preliminary appetite for an unmanned alternative to unacceptable pilot losses. These weapons proved very successful as a shock and surprise weapon. Thus, UAVs impacted the homeland defense strategy of most of the major powers in Europe and set in motion the timeless quest for nations to protect their citizens from aerial attacks (manned or unmanned).

Military leaders from Britain and Russia focused research efforts on Cruise Missile technology and target drones for their highly maneuverable fighters instead of reconnaissance and attack UAVs (Reed, 1979, 5). The British were mainly interested in stand-off weapon systems with a nuclear warhead that could be launched by their long-range bomber force. The Blue Steel weapon carried an autopilot, onboard computer, electrically operated flying controls and was launched from the belly of the bomber aircraft (Armitage, 1988, 58). The Soviets cruise missile program concentrated on designing systems to counter U.S. maritime assets. The AS-3 Kangaroo and AS-15 air-to-surface missile were launched from Badger bombers and carried a nuclear or conventional warhead and is presumed to have similar guidance systems to the U.S. (Armitage 1988) Since cruise missiles are exclusively expendable unmanned systems, the balance of this historical review of UAVs will focus on target drone design in the U.S. and subsequent unmanned systems in military operations.

#### Drones Research in the U.S.

Target drones or pilotless target aircraft (PTA) have served all branches of the U.S. military well from the humble beginnings in 1950 until the late 1990s. World War II ended and UAV research and development in the U.S. slowed dramatically, until the Cold War commenced with the Soviet Union. Once again, the nation refocused on the advantages of UAVs. Drone or PTA research and upgrades during the 1950s reached new heights. Target training drones were designed for all three branches of the service and the Canadian Air Force between 1950 and 1980.

Air Force and Naval Fighter Pilots. The USAF and USN commissioned Teledyne Ryan to design targets to hone the pilot's skills in air-to-air engagements. The first target drone, the Firebee I was air or ground launchable, parachute recoverable and controlled by UHF radio from the ground or air (Armitage, 1988, 65). The Firebee flew at 521 knots, sported ECM, active and passive radar augmenters, flares and low altitude systems and flew as high as 40,000 feet (Wagner and Sloan, 1992, 16-21). The ECM packages, radar augmenters and flares were an

essential survivability feature to protect the target drone, by confusing the guided missiles launched from attacking fighters or surface threats. As fighter aircraft and missile capabilities improved, the need for more realistic or fighter-like target drones increased. The supersonic speed, improved ECM package, 9g load and overall maneuverability of the Firebee II made it ideal for air-to-air training.

The USAF incorporated the Firebee II at the 1976 William Tell air-to-air competition at Tyndall Air Force Base, Florida. The supersonic Firebee II gave the pilots a run for their money during 22 engagements, zero Firebee II target drones were killed. Augmentation devices designed for the drones convinced radar that a small fighter or large bomber was approaching (Wagner, 1982, 90). This deception tool would find a place on future UAV designs to simulate fighter raids into enemy territory, allowing manned aircraft to slip through, undetected to engage targets. The maneuverability and survivability of the Firebee II target drones in the air-to-air role made their adaptation as scout-hunter, radar decoys in military operations possible.

Naval and Army Gunnery Units. The Army and Navy required a supersonic target drone to test the mettle of ground-to-air gunnery units. The Ryan Firebee II was commissioned to fulfill the task. Firebee II flew Mach 1.68 at 63,000 feet and 5 g maneuvers at 20,000 feet meeting all Service Component's requirements. The Navy was the first to take delivery of the Firebee II in July 1971 and rapidly set about honing the skills of missile defense and aviation personnel.

In 1972, naval forces from the U.S. Atlantic Fleet, British, and West German navies conducted a joint training exercise at Rosie Roads, Puerto Rico engaging 7 supersonic Firebee II and 25 Firebee I PTAs testing the surface-to-air and air-to-air capabilities of their crews (Wagner and Sloan, 1992, 21-23). Launch operations for the target drones took place from three sources depending on the time of day--off a nearby Island, aircraft, or a launch boat for night operations. The versatility of launch platform technologies for these target drones has been incorporated in various modern-day UAV systems.

Later, the Firebee II was upgraded with the Radar Altimeter Low Altitude Control System (RALACS) to skim over the surface of the water and avoid radar detection. The RALACS technology would appear later in a UAV designed for low level reconnaissance in adverse weather conditions. The basic design of the Firebee II, with some maneuverability and ECM upgrades is still used today for air-to-air combat training around the world.

While the Navy and Air Force incorporated the Firebee II into their training regimen in the air and over the seas, the Army engaged the Firebee at the White Sands Missile Range in New Mexico . The Army developed the 'Hawk' missile, the 'Chaparral,' and other surface-to-air systems (Wagner and Sloan, 1992, 84). In this case, the designers improvised the idea of the target drone's role by attaching a cylindrical, high-intensity infrared source to the Firebee. The Firebee variant, launched by a rail system and later a 11,000-pound-thrust jet assisted take off (JATO) bottle and engine power, served as the 'mother-drone' towing the target along for the Hawk missile to attack (Wagner, 1982, 89). These JATO launched Firebee variants facilitated the idea that drones could carry a significant payload, a 1000lb sensor or weapon in future designs. Another advantage of drone research was a solution for alternative launch sites to the heavily used White Sands Missile Range fixed sites. Identifying a need for alternative launch sites, a Ryan Aero manager designed a mobile launcher from a surplus Army flat-bed trailer (Wagner and Sloan ,1992, 85). The fielding of the mobile launcher made the idea of using modified drones in austere conditions and operational environments feasible. In fact, the mobile launcher served as the forerunner to the highly capable mobile launchers used today.

When the Stinger missile was designed, Army Missile Command (MICOM) at Huntsville, Alabama required a subsonic target in excess of 600 knots coupled with high G maneuvering turns to improve performance in surface-to-air operations. The reengined Firebee trained missile crews throughout the 1970s and 1980s, including Patriot antimissile crews who operated in Desert Storm against Scud missiles launched against Israel and Saudi Arabia (Wagner



and Sloan, 1992, 87). The technology improvements made to hone the skills of soldiers, sailors, marines, and airmen during training engagements have contributed to the extensive missions UAVs flew in Southeast Asia.

### Cold War

The downing of Francis Gary Powers' U-2 reconnaissance plane by an SA-2 missile on 1 May 1960 mobilized the U.S. political, military, and scientific communities in a quest to save face and protect aviators from capture (Wagner and Sloan, 1992, 1). High-altitude reconnaissance drones and photoreconnaissance satellites increased in popularity, although the resolution of the imagery was inferior to the U-2. The Air Force concentrated on developing the manned SR-71 supersonic, ultrahigh altitude reconnaissance jet instead of the newcomers to the field (UAVs). Due to fiscal limitations, only one research and development technology would be resourced. The manned SR-71 maintained a larger support base in Congress and the USAF. Also, USAF bias against unmanned systems partially due to the extreme secrecy of the operation and mistrust of any machine performing a man's role, left the UAV on the losing end of the research and development resourcing pool.

The UAV simply could not compete against a military culture built upon the primacy of manned flight, caught in a military drawdown. Additionally, at this point in their development, UAVs were not technologically feasible as a reliable instrument of warfare. The absence of near real-time data downlink, extended range command and control systems and multiple payload capacity limited the viability of UAVs over manned flight; therefore, no practical military leader would totally abandon manned flight research and development. On 27 October 1962, the second U-2 was shot down over Cuba by a Soviet surface-to-air missile (SAM) mobilizing the DoD and USAF to once again seek an unmanned reconnaissance alternative (Jones, 1997, 4).

In response to the search for an unmanned reconnaissance platform, Ryan Aeronautical and the Air Force modified a target drone airframe in 1963. The expanded wing span increased

UAV ceiling height to 62,500 feet and extended range to 1,680 nautical miles. An improved navigation system with an onboard programmer to correct the autopilot and improved stability to carry multiple cameras enhanced the "Lightning Bug" UAV (Armitage, 1988, 68). Initially, the Lightning Bug executed only preprogrammed mission profiles, receiving updates every seven miles with a backup system based on elapsed time from launch. After multiple drones were lost, five of seven successful missions, the command and control and recovery operations were strengthened through airborne controllers on the DC-130 launch platform.

The AQM-34 Ryan Aeronautical Lightning Bug reemerged as a photoreconnaissance UAV in the Vietnam War. The reconnaissance RPV equipped with a parachute recovery system were air launched from a DC-130 cargo plane by Air Force and civilian personnel, called direct control operators (DCOs). The initial missions were high-altitude, day photo sorties at altitudes above 50,000 feet, capturing high-resolution photography from politically denied territory for fighter and bomber units to strike (Wagner and Sloan, 1992, 3). The territory photographed by the Lightning Bug UAV was not too hostile for manned flight, but UAVs were flown during U.S. government-declared pauses in air attacks against North Vietnam where presence of manned reconnaissance platforms remained politically sensitive. Thus, UAVs collected the necessary, timely intelligence needed by USAF fighter and bomber commands to prosecute air operations.

When weather conditions turned sour for reconnaissance flights, the U.S. research and development community and Ryan Aeronautical designed the barometric low-altitude control system (BLACS), making unmanned missions below 1,000 feet a reality. The BLACS design would later reveal detailed enemy antiaircraft artillery (AAA) sites and troop concentrations previously undiscovered by reconnaissance assets. Additionally, the Teledyne Ryan Firebee performed low-altitude reconnaissance and served as the prime battle damage assessment (BDA) platform sending back live pictures to rear command centers (Reed, 1979, 24).

One additional technological advance with far-reaching impact was the mid-air retrieval system (MARS). The Navy identified a need for an alternate recovery method to the parachute free fall since recovery operations were extensive due to saltwater decontamination requirements aboard ship. Researchers designed a system for helicopters to snatch the descending RPV in mid air and return it to the aircraft carrier or land base for Air Force units. The MARS system undoubtedly extended the life and turnaround time of RPVs often damaged by landings in the jungles and rice paddies.

#### North Korea

In the war with North Korea, the joint military-industrial research community answered the need for an unmanned alternative. A new higher performance Ryan 147T model with refined engine performance, extended range and altitude, and evasive tactics covered the North Korean, Chinese, and Russian communications and radar; as well as the Korean demilitarized zone (DMZ) two years after the cease-fire. The Ryan 147TE, "Combat Dawn" ELINT model maneuvered out of the way of SA-2 launches, intercepted signals from target transmitters 600 miles away and transmitted signals back to U.S. ground stations in real time through a relay system (Wagner and Sloan, 1992, 9). The survivability and reliability of the Ryan 147 series of UAVs was demonstrated by the 1,651 operational missions flown by 100 UAVs averaging 7.3 missions, five missions greater than design projections (Armitage, 1988, 76). The need for comprehensive ELINT and electronic countermeasures (ECM) in Korea, led to the design of a capable, battle-tested line of RPVs modified for use in combat in the Middle East in the 1980s.

#### Vietnam

During the Vietnam War, Lightning Bug capabilities evolved to not only support photographic missions, but subsequent modifications also supported near real-time video transmission. Lightning Bug UAVs conducted ELINT and ECM, near real-time communications intelligence (COMINT) missions that increased the safety of manned aircraft flying over hostile

areas (Jones, 1997, 5). A psychological operations UAV program, Project Litter Bug dispensed leaflets deep into enemy territory to deliver personal messages from President Nixon urging the Vietnamese to give up the struggle.

Overall, the Ryan UAV family successfully executed the reconnaissance and ELINT missions, delivered crucial intelligence that saved countless American lives, while experiencing minimal losses. The Strategic Air Command (SAC) 100<sup>th</sup> Strategic Reconnaissance Wing (SRW) and a team of Ryan specialists operated the Ryan family of UAVs out of Kadena Air Base, Japan and Bien Hoa Air Base, South Vietnam, north of Saigon (Jones, 1997, 9).

A testament to the survivability of the UAV in air-to-air engagements was demonstrated on 31 December 1968 when a reconnaissance platform tasked to gather infrared photo imagery in the Hanoi area survived air-to-air engagement by MIG-21 aircraft. The 147 SRE reconnaissance UAV was exiting the Haiphong Harbor when the Navy informed airborne controllers on the DC-130 that MIG-21s were closing in on the UAV. The DC-130 controllers switched to program recovery override just as the MIGs closed to eight miles and executed the maximum rate of climb, leaving the MIGs without a target (Wagner, 1982, 144). The 147 SRE recovered safely and provided extensive night photo reconnaissance to U.S. forces.

Another family of UAVs, the Ryan 147F was modified as a dual ECM photoreconnaissance platform. During the second sortie of the day on 22 July 1966, the Ryan 147F platform drew ten SAMs for accompanying fighter aircraft to destroy before the UAV was struck (Armitage, 1988, 74). This tactic of scout-hunter attack proved very effective in destroying North Vietnamese missiles. Later, UAV decoy missions were flown successfully with the B-52 Linebacker II offensive.

UAV missions in Vietnam crossed the spectrum of employment in combat and secured a future for global employment. The average life of all RPVs launched in Vietnam was 3.5 missions; however, several RPVs completed forty–sixty missions (Wagner and Sloan, 1992, 6).

The accomplishments were noteworthy for the Lightning Bug UAV family. The Lightning Bug identified the first photographs of SA-2 missiles, Soviet MIG-21 aircraft, and Soviet helicopters in North Vietnam, photographed the closest SA-2 missile detonation (20-30 feet) on record in 1966 and served as the sole source of BDA of Linebacker II B-52 raids (Jones, 1997, 10).

In June 1969, an Air Force EC-121 electronic countermeasures aircraft was shot down by two MIG interceptors off the North Korean coast with thirty-one men aboard (Armitage, 1988, 76). The standard EC-121 mission involved flying within the detection of North Korean radar to collect communication and electronic intelligence. The crew listened to verbal radio transmissions by the enemy, detected the frequencies of the SAM missile launch sites and guidance systems of the missiles. The crew transmitted that information to B-47 aircraft well out of target range and disseminated the data to defense centers throughout the theater (Wagner and Sloan, 1992, 9). Faced with strong antiwar sentiment in the U.S., President Nixon canceled the EC-121 missions, leaving a gap in operational requirements for the Southeast Asia theater.

### China

When China was identified as a potential threat, UAVs equipped with infrared cameras performed high-altitude nighttime reconnaissance. Combat Dawn was the code name for UAV operations in the Southeast Asia Theater. The Ryan 147B Lightning Bug flew reconnaissance missions over China starting in August 1964. Two of the 147B UAVs were shot down in China, but the intelligence community refused to confirm the Chinese allegations against U.S. imperialism and worked in conjunction with Ryan and the Air Force to upgrade reconnaissance assets. Compass Cope-R was the name of one of the later reconnaissance High-Altitude, Long-Endurance prototype UAVs. The Cope-R was designed with an unrefueled endurance of thirty hours, an inward-canted fuselage (forerunner of stealth technology) to reduce radar reflectivity, and landing gear for takeoff and recovery on runways (Wagner and Sloan, 1992, 112). The

reduced radar reflectivity UAV technology improvements migrated into later designs of manned aircraft, SR-71 Black Bird and the F-117 Stealth Fighter.

#### Post-Southeast Asia UAV Program

The UAVs as strike platforms were investigated after the pullout from Southeast Asia. The 6514<sup>th</sup> Drone Test Squadron and Teledyne Ryan combined efforts at the Utah Dugway proving grounds fielding a proof of concept UAV capable of launching self-propelled air-to-surface missiles and AGM-65 Maverick TV-Guided missiles (Wagner and Sloan, 1992, 101). The Ryan 234 was launched from a DC-130 aircraft at 9,000 feet, descended to under 1,000 feet on an attack course toward a simulated SAM site. Five miles from the target, the UAV controller identified the target, armed the Maverick missile, scored a direct hit, and recovered the attack platform (Armitage, 1988, 81). The craft carried a laser designator and low-light level TV camera in the nose and was later modified with a low level navigation package for operations in the weather and terrain of Germany. Budget cuts and a change in focus for Air Force aircraft placed this unique UAV strike capability on the shelf.

The year, 1969 was the peak time for UAV operations with an estimated \$100 million or more a year spent on designing and fielding unmanned aircraft of many types (Reed, 1979, 72). Abruptly halted in 1972, President Richard Nixon suddenly engaged in détente with the Communist Chinese. He ordered a halt to UAV flights across China's territory as part of the peace initiative. Shortly after the halt of UAV flights in China, Tactical Air Command (TAC), forerunner of Air Combat Command--took control of the UAV force. In 1979, TAC preoccupied with manned reconnaissance production, failed to appreciate the utility of the Ryan family of drones and retired the force (Jones, 1997, 12). The proponents of UAV platforms were unable to convince the Air Force tactical fighter community to support the program and once again, UAVs fell from the U.S. radarscope of significant military hardware.

### Israeli Air Force

The Israelis on the other hand, made great strides in UAV research and employment during the early 1970s and those technological advantages are apparent even today. In the mid 1970s, Israel received thirty-three of the refurbished “stealthy” Ryan AQM-34s retired by Tactical Air Command (Jones, 1997, 12). The Israeli Defense Force recognized the utility of employing these unmanned aircraft in the ongoing conflict with their neighbors, Syria and Egypt. In August 1970, Russian SAM and AAA batteries were placed by the Arabs along the West Bank of the Suez Canal. Israeli Prime Minister Golda Meir requested assistance from the U.S. to strike the sites. The Department of Defense refused to use manned aircraft, but approved a ‘Defense Suppression’ UAV contract with Teledyne Ryan Corporation. Integrating six special purpose aircraft, Teledyne Ryan designed a UAV capable of firing a guided air-to-surface missile and transmitting TV camera image of terrain and targets (Wagner and Sloan, 1992, 98). The Israeli Air Force flew Teledyne Ryan Firebees on photographic missions over Egypt and Syria delivering critical intelligence on troop, tank and aircraft locations (Reed, 1979, 24).

In the October 1973 Yom Kippur War, RPVs launched on a base survey over Egypt. One account of RPV resilience and remote control operator (RCO) ingenuity describes a UAV digital programmer and auto-photographing command failure enroute to Cairo. The RCO directed the radar technician to send camera start/stop commands while he remotely guided the UAV along an altered route. On the return trip, the UAV temporarily lost radar communication but maintained its last heading and altitude in spite of MIG-21 aircraft and missiles launched against the craft. Crossing the Suez Canal, the UAV was identified, communication was reestablished and the craft recovered to a safe landing (Wagner and Sloan, 1992, 63). During the Yom Kippur War, UAVs were used as decoys to draw enemy surface-to-air missile fire for the Israeli Air Force fighter and bombers to target. The Israeli Air Force study of UAV usage in previous conflicts was apparent.

These same tactics of scout-hunter (unmanned decoy and manned strike) were used by U.S. forces in Vietnam.

Additionally, Israel demonstrated the effectiveness of UAVs in a coordinated air strike on Syrian SAM sites in 1982. Initially, Israel used the UAV as a reconnaissance platform against Syrian SAM sites. Once those SAM sites were identified, Israeli UAV controllers designed a well-orchestrated fighter-UAV strike. During the main raid, the first wave of UAVs served as airborne deception decoys ahead of the attacking fighters, while the follow-on wave of UAVs served as jamming platforms (Edwards, 1990, 7). The Israeli Air Force embraced the advantages UAVs brought to the battlefield in the form of intelligence, surveillance, and reconnaissance as well as electromagnetic warfare while mastering effectively the combined operations of manned and unmanned systems to accomplish military objectives.

#### Desert Storm

In January 1991, the joint Israeli-U.S. designed "Pioneer" UAV was used for over-the-horizon (OTH) targeting, reconnaissance and battle damage assessment (BDA) for commanders in Desert Storm. The forty-three Pioneer UAVs flew 330 sorties, totaling over 1,000 flight hours, and provided near real time reconnaissance to U.S. Army commanders conducting the envelopment of Iraqi forces (Jones, 1997, 19). The ground forces leveraged the reconnaissance, surveillance, targeting acquisition (RSTA) capabilities of Pioneer to surprise, outmaneuver, and destroy enemy artillery and Iraqi forces in the Kuwaiti Theater of Operations (KTO). The Navy harnessed the unique capabilities of the Pioneer UAV to monitor the Kuwaiti coastline and Iraqi naval facilities, spot mines in the littoral area and adjust naval gun fire (Jones, 1997, 19). The nine systems currently in U.S. service made over 5,000 flights, and logged nearly 12,000 flight hours by July 1995, with a sortie availability rate of better than 85 percent (Munson, 1997, JUA VT I-7). Based on Desert Storm successes, Pioneer was sought by other CINCs to conduct BDA, reconnaissance, OTH targeting and mine hunting in Somalia, Haiti and Bosnia.



### UAV Systems of the 1990s

A quick review of the historical highlights of UAV usage in warfare and regional conflicts clearly demonstrates the military advantages when unmanned systems are integrated into the overall scheme of maneuver and properly sequenced with manned weapon systems. The trend in UAV technology capitalizes on the lessons learned from past designs and improves engine performance and endurance while often fielding smaller, more lethal, maneuverable vehicles. A brief survey of the current U.S. UAV systems will provide a jump off point to evaluate the viability of emerging technologies to perform alternative missions to the standard RSTA role.

Pioneer. The Pioneer is a UAV system acquired from non-developmental technology allowing the USN to quickly procure a small quantity of systems for a competitive fly off in 1985 (Green, 1995, 10). Although, the USN initiated the procurement for shipboard and land-based operations, the USA and USMC soon acquired Pioneer systems for BDA, reconnaissance, and target selection. The Navy maintained five systems while the Marine Corps and Army maintained two systems respectively. The Pioneer was used extensively by naval and ground forces during Desert Storm conducting over 300 combat missions with only one shoot down (Green, 1995, 11). From 1994 through 1997, Pioneer flew missions over Haiti, Somalia and Bosnia supporting NATO peace forces, monitoring population centers, searching for terrorists and providing near-real time reconnaissance (UAV Annual Report, 1997, 24). The responsiveness of the Pioneer UAV and versatility of the sensor packages earned a permanent place for unmanned systems in the U.S. reconnaissance inventory.

What equipment made Pioneer so well suited for RSTA missions in MOOTW and warfare? The Pioneer system carried electro-optical (EO) and infrared (IR) sensor packages to deliver imagery during day and night operations. The Pioneer UAV platform operated up to 15,000 ft at 120 km/hr. The Pioneer operated at a 100nm (185km) radius with 5 hours endurance

under the control of one ground control station, one truck-mounted launch vehicle and up to 4 remote receiving stations (UAV Annual Report, 1997, 24). Although, this system did not perform different missions from UAVs in Southeast Asia, the Pioneer's employment at the tactical level (Corps and below) dramatically changed the image of the UAV as a battlefield combat multiplier. The reliability, flexibility, speed and endurance of the Pioneer UAV gave ground commanders an ideal platform to extend their eyes and close the gap on manned and space-based reconnaissance assets dedicated to the tactical fight.

Hunter. Faced with the retirement of the RF-4C reconnaissance platform, the Army, Navy and Marine Corps desired a longer-range tactical UAV (200nm radius), one leap in technology above the Pioneer UAV system. With the DoD shift to a Joint UAV Project Office in late 1988, a UAV Master Plan was designed to project all Service needs for Cruise Missiles and UAVs with the goal to eliminate redundancy and save money on Research and Development. The Joint Tactical UAV or Hunter UAV system was the first system procured under the new Joint UAV Project Office. This new Joint UAV Project Office levied an extensive list of performance requirements on Hunter to satisfy both ship and shore operations (Green, 1995, 13). The extensive performance requirements, competing Service component priorities and rising design costs invited scrutiny from the Joint Requirements Oversight Council (JROC). JROC recommended ending the acquisition program after delivery of seven systems, 45 short of the planned total (Jones, 1997, 21).

Despite curtailed acquisition and full operational fielding, the Hunter UAV system served a useful purpose as a test-bed platform for UAV doctrine and concepts. Hunter provided near real-time imagery within a 200km radius, extendible to 300+km with an airborne relay, operated from unimproved airfields capable of supporting ground commanders at the forward line of troops (FLOT) and illuminated targets for precision guided munitions (PGM) fired from manned systems (Jones, 1997, 21). Although, the Service Components attempted to do too much with

one system, the joint UAV program office process identified the cost overruns, justifiably curtailed the project and captured lessons learned for future UAV buys.

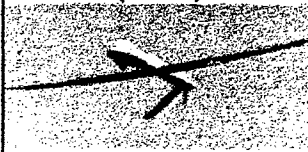


Predator. The Predator UAV, formerly called the Tier II UAV (a Gnat 750 derivative) reached its current prominent position in the reconnaissance role for theater CINCs worldwide through the concepts advanced by the joint UAV program office experience with the Hunter UAV system and intelligence collection gaps in Desert Storm. The DoD Advanced Research Projects Agency (DARPA) was commissioned in 1993 by the Joint Chiefs of Staff and DoD to design and test a small number of UAV platforms, evaluating utility, concept of operations, cost and performance (Green, 1995, 31).

Predator was expected to provide long-range, extended loiter, near real-time imagery, and all-weather reconnaissance to the tactical ground commanders. Constructed of lightweight composite materials, the Predator is extremely difficult to detect with radar and almost invisible to optical, acoustic and infrared sensors, greatly enhancing its' survivability (Green, 1995, 35). The Predator system consists of three subsystems: an air platform with electro-optical, infrared, and synthetic aperture "commercial off-the-shelf" sensors, the ground control station and the data dissemination system allowing airborne retasking (Jones, 1997, 30). The Predator's data dissemination system uses satellite communication links to broadcast live video to commanders at the tactical, operational, and strategic level and serves a critical new role for the battlefield commander to view operations as they develop. This new capability was demonstrated in December 1995 when the Predator broadcast critical intelligence to NATO commanders regarding a violation on weapon's movement in Bosnia, leading to a successful bombing campaign and subsequent agreement by warring parties at the Dayton Peace Accords.

The Predator transitioned from an advanced concept technology demonstration (ACTD) to full production in August 1997, and has maintained a constant presence in NATO operations in Bosnia (UAV Annual Report, 1997, 30). Although, Predator has encountered some limitations in

high winds and precipitation, the system has performed the reconnaissance mission beyond all expectations. Predator staged 294 missions out of Taszar, Hungary from March 1996 to September 1997, broadcasting imagery of helicopter staging areas, cantonment areas, mass grave sites, equipment assembly areas, storage sites, and civilian/military personnel movements to enforce Dayton Peace Accords and enhance peacekeeping operations (UAV Annual Report, 1997, 31). The prevalent use of the Predator for reconnaissance in MOOTW and routine joint in-theater training has forced the Joint Staff and aviators to reevaluate airspace control issues for simultaneous manned and unmanned platforms. The issue of UAV doctrine will be addressed later in chapter 4.

TABLE 1. Air Force Unmanned Aerial Vehicles

<i>Air Vehicle Data</i>		<i>Payload</i>	<i>Status</i>
<b>Tier 2 Predator (\$3.2M)</b> 	Gross Wt (lb) - 2,000 Altitude (ft) - 25,000 Endurance (hr) - 50+ Payload (lb) - 450 Wingspan (ft) - 49 Airspeed (kts) - 80	SAR - 3 m, 0.3 m EO/IR - NIIRS 6.5 Ku, UHF SATCOM CDL, UHF LOS Comm	Operational
<b>Tier 2+ Global Hawk (\$10M)</b> 	Gross Wt (lb) - 24,000 Altitude (ft) - 65,000 Endurance (hr) - 42 Payload (lb) - 2,000 Wingspan (ft) - 116 Airspeed (kts) - 300	SAR - 3 m, 0.3 m to 200 km EO/IR - NIIRS 6.5/5/5 Ku, UHF SATCOM CDL, UHF LOS Comm	In Build
<b>Tier 3- DarkStar (\$10M)</b> 	Gross Wt (lb) - 8,600 Altitude (ft) - 45,000 Endurance (hr) - >8 Payload (lb) - 1,000 Wingspan (ft) - 69 Airspeed (kts) - 350	SAR - 3 m, 0.3 m EO/IR - NIIRS 5 Ku, UHF SATCOM CDL, UHF LOS Comm	In Test (#1 Crashed)

Source: *Report on UAV Technologies and Combat Operations* (Worch, 1996, 1-2).

Global Hawk. The Global Hawk UAV is designed by Teledyne Ryan Aeronautical as a long-range, high-altitude endurance (HAE) system. Global Hawk's high altitude capability avoids most ground threats and permits the multi-sensor payload to view the battlefield and transmit near real-time imagery to senior command echelons. The Global Hawk performance objectives developed from Mission Needs Statements for long endurance RSTA capability, broad area coverage imaging capability and assured receipt of imagery for tactical forces (Jones, 1997, 35). The Global Hawk flew its first flight on 28 February 1998 achieving an altitude of 32,000 feet. The Global Hawk payload demonstrations continue through December 1999 when DARPA recommends transition to operational status or termination of the project.

DarkStar. The DarkStar is a low-observable UAV developed by Lockheed Martin Skunk Works and Boeing for DARPA to provide high-altitude battlefield surveillance in high threat environments. The DarkStar experienced early difficulties when the second test vehicle crashed during landing. Sacrificing payload and range for survivability measures, the DarkStar was designed as a complementary system to the Global Hawk. In January 1999, the Pentagon terminated the DarkStar program citing range and loiter time as the rationale. The remaining money will be shifted to refine the Global Hawk UAV capability.

#### Summary

Since inception in World War II, unmanned aerial vehicles were hastily constructed to meet a military need where the environment was either too hostile or politically undesirable for manned flight operations. In order to survive in a complicated, combat environment UAVs experienced in-the-field modifications and on-the-job testing as a matter of routine operations, and thrived under these conditions. Warfare in Vietnam and other countries in Southeast Asia presented difficulties for air operations. The dispersion and large number of enemy forces required a highly responsive, survivable and adaptable reconnaissance platform to locate, identify and transmit valuable imagery and ELINT to tactical and operational commanders. The

unmanned aerial vehicle proved the ideal platform for Southeast Asia operations. As budget cuts abounded and the immediate threat of armed conflict waned, UAV development became limited in scope. UAV design shifted mainly to target drones. Operation Desert Storm in the Persian Gulf and Joint Endeavor in Bosnia saw a reemergence of UAV technology and employment as a reconnaissance platform at the same time that the Department of Defense was restructuring to save research and development costs through joint acquisition programs. This complementary set of circumstances ushered in the second heyday for UAV design, testing, development and funding. UAV systems in the 1990s integrated commercial off-the-shelf technology, designed modular sensor packages with growth capacity and rapidly responded to the needs of the Joint Force and the Theater CINCs. With the accelerated design of lightweight composite materials, precise navigation packages, pinpoint target sensors, and increased payload capacity, the expansion of UAV missions are limited only by doctrine and the imagination.

## CHAPTER 3

### CAS DOCTRINE, AIRCRAFT, FUTURE APPLICATION

Because of its independence of surface limitations and its superior speed the airplane is the offensive weapon par excellence (Douhet, 1921, 15).

#### History

Close Air Support has existed in the pure sense of air support to ground forces since inception in World War I with German and Allied Air Forces. A group of air pioneers and extremely brave and financially influential officers around the world experimented with aircraft that could not only observe enemy forces but deliver ordnance to protect ground forces. A number of key points in history highlight the significant contributions and essential characteristics for effective Close Air Support (CAS) aircraft.

#### Advance Across France (1 August-15 September 1944)

Brigadier General D. P. Weyland of the XIX TAC designed the tactic of armed reconnaissance; aircraft attacked enemy troops and armored columns on the move ahead of advancing friendly forces. Lieutenant General George Patton's forces, often advanced hundreds of miles from command headquarters in pursuit of the retreating German forces requiring the use of forward ground controllers to orchestrate the CAS packages. The armed reconnaissance aircraft located and destroyed troop concentrations, tanks, vehicles, and enemy freedom of movement, often defeating in minutes what would have taken ground forces hours to defeat. Some great initiatives made these results possible. American vehicles had fresh white stars and yellow panels for easy identification by friendly aircraft and conversely facilitated easy identification of enemy targets. Another significant tactic, ground forces identified a bomb line clearly separating friendly and enemy forces. This bomb line served as an early form of the Fire Support Coordination Line (FSCL) or Kill Box (line of death) coordination strategy, beyond which only targets abounded.

During the advance across France, the Allies, especially the U. S., experienced great technological advances in the area of weapons. The plethora of CAS weapons including machineguns, general purpose bombs, rockets and fragmentation bombs combined into a complimentary ordnance mix and proved effective against troops, fixed fortifications and armored vehicles (Cooling, 1990, 250). The CAS platform essentials of friendly force identification, target confirmation and discrimination, weapon accuracy and lethality, and interoperable communications had a significant impact upon the successful, rapid Allied advance across France in 1944.

#### Defense of Pusan Perimeter (July-September 1950)

Major General Earle Partridge employed Fifth Air Force assets against six North Korean divisions threatening the Eighth Army under the command of Lieutenant General Walton H. Walker around the crucial Port of Pusan. The United Nations (UN) forces suffered numerous defeats, leaving friendly forces with a meager foothold on the Korean peninsula, a defensive perimeter around Pusan, the key sea lane of communication. The Far East Air Forces (FEAF) conducted a 340 fighter-bomber sorties per day operation for ten days from 1-10 August 1950 and a 239 sorties/day operation for the balance of the Pusan Perimeter operation, with tremendous results (Goldberg, 1957, 246).

The massing of such large numbers of CAS aircraft into such a small area demanded extreme weapons accuracy, airframe reliability, extensive loiter time, and interoperable communications, coupled with a responsive command and control infrastructure. The intensity of CAS efforts served to keep the North Koreans in check. One ground commander defending the Pusan Perimeter offered a first-hand glimpse into some CAS strike results. Major General Laurence B. Keiser, commander of the 2d Infantry Division, credited the combined air-ground team with destroying 1500 enemy troops and accompanying equipment during a one-day offensive (Goldberg, 1957, 247). Prior to 1950, U N and U. S. forces experienced thousands of



casualties and accompanying equipment destruction. This astounding turn of the tide by CAS assets broke a military stalemate, helped ground forces stay on the peninsula and helped set the conditions for the breakout of the Pusan Perimeter. As a result, the division commanders repeatedly praised the FEAF as the key factor that saved their divisions from destruction (Goldberg, 1957, 248). The CAS platform strengths of maintainability, reliability, interoperable communications, weapon accuracy, and weapon lethality were the instruments which proved effective in maintaining ground force gains in the Korean area of operations.

#### Southeast Asia--Vietnam

CAS in Vietnam was a complicated operation, due to dense jungle, uneven terrain, adverse weather conditions, and counterinsurgency small-unit tactics demanding doctrinal adaptations. High performance jet aircraft offered short loiter time and encountered problems identifying small, mobile targets in the dense foliage at high speeds and low altitudes (Cooling, 1990, 444). These CAS shortfalls, coupled with routine enemy night attacks provided an opening for the AC-47 "Spooky" and follow-on AC-130 "Spectre" Gunship to enter the world of night CAS. The Gunship's extended loiter time, rapid response time and great firepower rate rendered outstanding results in night and adverse weather operations. The Gunship is credited with defense of 500 outposts in one year's time with a twenty-four minute response time (nearly half the time of jets), high power flares, and massive amounts of rounds--43,500 rounds during the 11 October 1966 defense of Kien Phong Province (Cooling, 1990, 445).

Other CAS platforms contributed to the security of ground forces during Vietnam. An isolated 6,000-man United States Marine-South Vietnamese Ranger outpost, Khe Sanh, along with continuous CAS withstood a seventy eight-day siege by North Vietnamese forces three times their number. The official State Department after-action report estimated 15,000 enemy killed in action and described Khe Sanh as the first major ground conflict won in part due to air power (Cooling, 1990, 453). The complexities of the Vietnam conflict, and the high toll in

casualties on both sides allowed CAS doctrine and platform capabilities to flourish. The CAS platform essentials of identification of friendly and enemy forces, target confirmation and discrimination, weapon accuracy and lethality, interoperable communications, all-weather operations and extended loiter time are recurring themes in the evolution of CAS in the Vietnamese conflict.

### Desert Storm

In late January 1991, Air Force, Navy, and Marine aircraft flew CAS missions against Iraqi forces threatening the U.S. Marine and multi-national positions in the town of Khafji, Saudi Arabia. On 29 January 1991, an Air Force E-8 JSTARS aircraft spotted Iraq's 5<sup>th</sup> MECH and 3<sup>rd</sup> Armored Division moving south across the Saudi border toward Khafji. Since the ground offensive was weeks away, the Joint Force Commander chose to tackle this Iraqi offensive with air power and the coalition forces already in place protecting the border. Air attacks were directed into the Kuwaiti Theater of Operations (KTO), using kill boxes of thirty by thirty kilometers. Four-ship flights of attack, fighter and bomber aircraft transitioned through the kill boxes for approximately eight minutes during daylight and fifteen minutes during nighttime operations (Grant, 1998, 31). Although, AAA and missiles occasionally launched against attacking aircraft, the rapidity of the attacks eliminated further Iraqi maneuver force initiatives, thus, increasing aircraft survivability. Less than forty-eight hours after commencing the offensive, Iraqi forces were in disarray and retreating.

An Iraqi soldier captured by 5<sup>th</sup> MECH claimed his brigade sustained greater damage in thirty minutes of air attacks at Khafji than eight years of fighting in the Iran-Iraq War (Grant, 1998, 32). Overall, the land war was so fast paced and the air war so thorough CAS sorties originally requested were not required on execution day. However, demonstrated platform strengths such as maneuverability and lethality, responsiveness, twenty-four hour sustained

operations, friendly and enemy discrimination and interoperable communications thwarted Iraqi offensive efforts for the remainder of Operation Desert Storm.

Although today's sophisticated sensors and weapon systems continue to improve the basic CAS concepts birthed in World War I, refined in Vietnam and decisively executed in Desert Storm, the fog and friction of warfare still demands a close air support infrastructure. This CAS infrastructure must deliver precise, lightning-quick coordination between land and aerospace forces in order to achieve the Joint Force Commander's objectives. The ultimate goal of military commanders, to achieve decisive victory with minimal loss of life continues to be greatly enhanced through effective day and night CAS.

#### Doctrine and Command and Control

The connective fiber between technologically sound CAS platforms and decisive victory in land warfare is streamlined, responsive command and control infrastructures bolstered by evolving doctrine. Joint publication 3-09.3 defines CAS as air action by fixed-wing and rotary-wing aircraft against hostile targets which are in close proximity (1-2 km) to friendly forces, and which require detailed integration of each air mission with the fire and movement of those forces. Key fundamentals for effective CAS are identification of all friendly forces through "eyes on", knowledge of the ground scheme of maneuver, detailed imagery of the target area, and up-to-date intelligence on the enemy disposition and positive control or reasonable assurance for weapons release authority. Due to these key CAS fundamentals, elaborate planning and execution cells operate during hostile military contingencies. Additionally, continuous Joint training occurs year-round in the National Training Centers, Joint Readiness Training Centers, and Combat Training Centers. The command and control (C2) system often proves the most complicated for CAS requesters to circulate through and understand. A quick snap shot of the system follows. The JFC exercises operational control through the various component commanders: USAF, USA, USN, USMC, and SOF. The JFC exercises control over CAS assets in joint operations through

the Joint Air Operations Center (JAOC). The JAOC houses representatives from all component commanders with air assets involved in the contingency and serves as the overarching ground based C2 element for the Joint Forces Air Component Commander (JFACC).

To execute centralized control, there are three complementary airborne C2 elements: the Airborne Warning and Control System (AWACS), the Airborne Battlefield Command and Control Center (ABCCC), and the Joint Surveillance and Targeting Acquisition Radar System (J-STARS), linking aerospace forces with land forces. The AWACS provides radar control, threat warning, and communication relay for transiting aircraft while the ABCCC manages the interface between aircrews and ground elements in the battle area. The J-STARS provides a detailed ground picture on troop concentrations, target arrays and troop movements.

Two key ground-based C2 elements interface with the airborne C2 elements, the Control and Reporting Center (CRC) and Air Support Operations Center (ASOC). These ground-based C2 elements extend the positive control and survivability mechanism for employing CAS assets. The CRC is a combination airspace control, air defense facility with mobile radar units to protect aircraft maneuver space. The ASOC is colocated with senior Army echelon's Fire Support Element processing requests for immediate CAS and tasking on-call CAS missions.

The final and often most critical link for employing CAS assets and preventing fratricide (friendly casualties due to friendly fire) is the Tactical Air Control Party (TACP). The TACP collocates with Army maneuver units from battalion to corps, providing 'eyes on' and communicating weapons release clearance. The synchronized ground-based and air-based C2 elements form the fundamental tenet of Aerospace Control--centralized control with decentralized execution.

With a responsive C2 system in place and properly configured CAS platforms, the JFC or the designated representative (normally the JFACC) plans for CAS employment during deep, close or rear operations. CAS employment ranges across the spectrum from support of Special

Operations Forces (SOF), conventional aviation forces, maneuver elements, to air base and logistics base defense. Irrespective of distinct ground maneuver forces supported, appropriate CAS employment requires specific preconditions and risk mitigation measures. These preconditions are detailed in table 2.

Table 2. Conditions for Effective Close Air Support

Condition	Benefit/Method
Air Superiority	Freedom of maneuver
Suppression of Enemy Air Defense-SEAD	CAS ops in heavily defended areas
Target Marking	Increase situational awareness (locate & attack proper targets faster)
Favorable Weather	Reduce requirements for aircraft radar equipment & ground beacon usage
Prompt Response	Streamlined request path, airborne alert, forward operating bases, delegate authority
Appropriate Ordnance	Tailored weapons packages
Communications	Reliable and interoperable
Command & Control	Integrated, flexible, deconflict fires/routing

(JP 3-09.3, 1995, 1-5).

#### CAS Platform Essentials

Provided the preconditions (table 2) of air superiority, suppression of enemy air defenses, interoperable communications, command and control, and operator skill are in place, what clearly constitutes a viable close air support platform? What are the essentials for the weapon system to be employed in a CAS role? Joint Publication 3-09.3 refers to requirements such as, identification of friendly forces, target confirmation and discrimination, weapon accuracy and lethality (includes appropriate ordnance mix to service target), interoperable communications and survivability. Based on historical examples, these requirements appear totally appropriate and enduring; however, assessments of future threats and force modernization highlight an expanded list of CAS platform characteristics.

The Air Force Chief of Staff in 1996 commissioned a study by the Air Command & Staff College (ACSC) to project CAS requirements in the fiscal year (FY) 2025 time frame. This Air Force 2025 CAS study evaluated the entire infrastructure for CAS, from the issue of C2 to weapons technology. The following CAS platform essentials were extracted from this study: friendly and enemy automatic discrimination technology; stealth technology and survivability features; weapons capacity, lethality and precision; extensive data fusion (harness, process and disseminate information); maintainability and reliability; and cost effectiveness. This expanded list of CAS platform essentials is reasonable in light of the accelerated impact of technology on warfare. Miniaturization and increased lethality of surface and air weapons require a more survivable platform to execute the CAS role in the *Joint Vision 2010* and subsequent threat environment.

#### Status of Current CAS Platforms

Based on the Air Force projection of CAS in 2025, how close do current CAS platforms match future expectations? When considering the best-suited platform for the CAS mission, a few select aircraft come to mind. Specifically, the A-10 Thunderbolt, the AV-8B Harrier, and the AC-130 Gunship stand among the front runners in prosecuting the close air support role in the joint operations arena. Other multirole fighters, like the F-16 Fighting Falcon and the F/A-18 Hornet, execute CAS missions when not engaged in the strategic attack, interdiction, naval support or counterair roles.

But what is the status of these multirole fighters in relation to the CAS role? The 1996, 1997, and 1998 *Annual Defense Review* addresses the modernization efforts and projected shortfalls in capability of these aircraft in the attack role. The older F-16 aircraft face significant upgrades to avionics, engine performance and survivability measures to achieve the desired 8,000 flying hour lifetime, an unprecedented operating life span twice that of any operational F-16 aircraft (ADR, 1996, 20-4). Previous fighter aircraft operated for twenty years or the equivalent

of 4,500 flying hours (ADR, 1998, 3-41). The Department of Defense considered refurbishment of existing aircraft more cost effective than purchasing additional new aircraft of existing types and programmed \$760 million to modernize Air Force tactical aircraft from FY 1999-2001 (ADR, 1996, 20-37). (Comparison costs of \$275 million for R D T & E of the Outrider, Predator and Endurance UAVs per fiscal year)

In 1997, the Department of Defense launched a new approach to filling the gap in ground attack fighters through a program to earmark 200 older, F-16 fighter aircraft in inactive storage for potential reactivation. The purpose of this program was to form a pool of aircraft to field two combat wings to offset aircraft withdrawn for unanticipated structural repairs or compensate for delays in the Joint Strike Fighter (JSF) program. Although reactivating older F-16s is not a preferred course of action, this stopgap measure offers a relatively low-cost fighter replenishment alternative. Attrition reserve F-16 aircraft are needed to maintain the 20-Fighter Wing Equivalent (FWE) force structure until the JSF enters service (ADR, 1997, 17-14). Due to budgetary constraints, the Air Force did not procure new F-16s in FY 1998. The recent sale of twenty-one aircraft to Egypt will keep the F-16 in production, until at least the year 2000, preserving production capability for JSF acquisition shortfalls (ADR, 1997, 17-47).

The F/A-18C/D Hornet is a much newer attack fighter with approximately twenty aircraft delivered in FY 1998. F404 engine availability for the F/A-18 has been a key readiness concern, since the F/A-18 accounts for more than 50 percent of the Department of the Navy's tactical aviation assets (ADR, 1998, 3-43). Introduction of redesigned components, coupled with funding increases, should alleviate any shortfalls in F404 replacement engines. Unexpected failures in critical components could adversely impact the F404 program. Initiatives to modify acquisition regulations on competition are expected to solve this readiness issue (ADR, 1996, 20-8).

The Navy considers the delivery of the F/A-18E/F engineering and manufacturing development upgrade a significant leap in technology and capability over the F/A-18C/D models.

However, the sheer numbers of the upgraded F/A-18E/F aircraft are incapable of meeting the full capacity of the aircraft carrier to project combat power (ADR, 1997, 17-48). Shortfalls highlighted by the Navy include an inability to interface with latest electronic countermeasure systems effectively and severe carrier recovery payload limitations (ADR, 1998, 3-43). Based on these capability gaps, additional F/A-18C/D aircraft will not be purchased by U.S. Naval Forces. Foreign sales to Finland, Malaysia, Switzerland, and Thailand will keep the production line open through FY 2000; the latest date for foreign deliveries (ADR, 1997, 17-48).

Compared with the C and D models, the F/A-18E/F will have significantly greater range, carrier payload recovery capability and survivability, function as a tanker for in-flight refueling, and offer growth capability and more payload flexibility (ADR, 1998, 3-43). The Navy and Marine Corps anticipate the fielding of the F/A-18E/F model around FY 2000, and the JSF around FY 2010 to answer shortfalls in capability for the ground attack role. Although experiencing some technical problems in operational testing, the F/A-18E/F procurement of 20 aircraft in FY 2000 remains funded contingent upon contractor resolution of wing-drop malfunctions and other program issues (ADR, 1998, 3-44). The delicate balance of modernization priorities will undoubtedly continue to impact the refurbishment of F-16 aircraft, acquisition of F/A-18E/F aircraft, and greatly increase the need for the JSF to be delivered on time at cost and to standard.

Air Force A-10 Thunderbolts are the workhorse and image of America's CAS weapon of choice. The A-10 entered operation in March 1976 and will receive modest upgrades to process high-speed tactical data and extend service life through FY 2020 (ADR, 1996, 20-35). The Active Air Force maintains 72 A-10 aircraft for CAS and Interdiction, and 72 OA-10 aircraft for Forward Air Controller duties. The Reserve Components maintain 88 A-10 aircraft for CAS and Interdiction, and 42 OA-10 aircraft for Forward Air Controller duties (ADR, 1998, 3-41). This post Desert Storm restructuring of A-10 units placed the largest number of dedicated CAS assets



outside the active duty force since mission inception. The Air Force earmarked sixty inactive A-10 aircraft for secure storage just in case they are needed for future reactivation. According to recent USAF estimates, these sixty earmarked aircraft are sufficient to offset future peacetime attrition and sustain the present OA-10 and A-10 force structure into the 2020s, the current projected service life of the A-10 (ADR, 1998, 3-41).

The AV-8B Harrier is doctrinally tied to the Marine Air Ground Task Force (MAGTF) for synchronizing maneuver and massing effects in a CAS role. The Marine AV-8B Harrier entered service in the late 1970s. Conversions of day-attack-only AV-8B airframes began in December 1995. Extending the service life and configuring latest night-attack/radar systems of the fleet should be completed in FY 2001 (ADR, 1996, 20-9). In 1996, the AV-8B remanufacturing program was on track with delivery of the first three refurbished aircraft. Current plans call for a total of 72 AV-8Bs to be remanufactured with significantly improved avionics and weapons provisions (ADR, 1997, 17-49). Despite GAO questions regarding the feasibility of continuing the remanufacturing program for the AV-8B, the Marine Corps pushed and earned a spot for funding twelve additional aircraft in the FY 1999 budget (ADR, 1998, 3-43). As long as the AV-8B upgrades continue, the MAGTF will greatly improve night CAS capabilities and extend the service life of existing CAS assets until the JSF is fielded to Air Force, Navy and Marine forces.

Approximately half of the Air Force Special Operations AC-130 Gunships entered service in 1995 and are forecast to remain viable through FY 2025, while the remaining older Gunships are nearing the end of their life expectancy around FY 2005. The existing Gunships are undergoing modernization constantly on weapons, sensors, and survivability measures, to maintain the edge of special operations forces. To meet the future needs of the SOF team, U. S. Special Operations Command and Air Force Special Operations Command are diligently evaluating current and future technologies to meet future firepower needs.

With these upgrades to extend service life of existing aging CAS weapon systems, the Department of Defense has accepted some risks, trusting procurement and budget allocations to maintain the continuity required for on-time delivery of the JSF. As a quick reference on current CAS aircraft, a compilation of CAS platform capabilities and weapons follow in table 3.

Table 3. Aircraft Weapons and Capabilities Guide

<b>Aircraft</b>	<b>Service</b>	<b>Ordinance</b>	<b>Laser</b>	<b>Marking Capability</b>	<b>Beacon Capability</b>	<b>Other Systems</b>
<b>AV-8B</b>	USMC	LGB, AGM-65, GP bombs, CBU's, 2.75" & 5.0" rockets, LUU-2 Flares, 25mm cannon, AGM-122 Sidearm	LST	Rockets	None	TV NVG GPS  +NVG FLIR RADAR
<b>A/O-10A</b>	USAF	LGB, AGM-65, GP bombs, CBU's, aerial mines, 2.75" rockets, LUU-1/2 flares, LUU-5/6 flares, 30mm cannon	LST	WP rockets 30mm HEI LUU-1 LUU-5 LUU-6	None	NVG
<b>AC-130</b>	USAF (SOF)	105mm Howitzer 40mm cannon 25mm cannon	LTD	GLINT 105mm WP 105mm HE 40mm MISCH LTD	PPN-19 SST-181  (SSB, PLS) H-model	FLIR ALLTV RADAR GPS
<b>F-16C/D</b>	USAF	LGB, AGM-65, GP bombs, CBU's, 20mm cannon	LTD	Laser	PPN-19 PPN-20	FLIR GPS NVG RADAR
<b>F/A-18</b>	USN USMC	LGB, AGM-65, AGM-84 SLAM, AGM-88 HARM, GP bombs, CBU's, aerial mines, LUU-2 Flares, 2.75" & 5.00" rockets, napalm/FAE, 20mm cannon	LST LTD	Laser WP rockets HE rockets	None	FLIR GPS NVG RADAR

(JP 3-09.3, 1995, Annex E).

### Future Short-Term CAS Initiatives

The multirole Joint Strike Fighter (JSF) is projected to enter the force in FY 2010 and replace Air Force F-16 and Navy and Marine F-14, F/A-18, and AV-8B aircraft. Just prior to delivery of the JSF (FY 2005 – FY 2010), the Air Force projects a shortage the equivalent of one wing of fighter aircraft (seventy-two combat aircraft) (ADR, 1997, 17-18). The Department of Defense anticipated development delays for the JSF and authorized program funds during FY 1999-2001 to improve existing fighters and garner “some mid-term hedges against force structure declines (ADR, 1996, 20-31).”

All three air power components, USAF, USN and USMC, have mortgaged a great portion of the attack fighter modernization budget on delivery of the anticipated, highly capable JSF. Some of the proposed armament characteristics of the JSF include two guided bombs, two medium-range air-to-air missiles internally, and wing-mounted weapons stations. The Navy professes that “the earlier F/A-18C/D model, while a very successful design, lacks the growth potential to keep pace with new technologies anticipated in future decades (ADR, 1998, 3-40).” Since the Navy plans to transition to JSF procurement, as soon as possible, acquisition objectives for F/A-18E/F have been reduced to between 548 and 785 aircraft. The JSF production should harness the anticipated significant improvements in survivability, avionics, and mission radius over the F/A-18E/F.

Initial production of the new JSF aircraft is FY 2005, with first deliveries to operational units in FY 2008 and initial operational capability around FY 2010 (ADR, 1997, 17-46). The Department must replace approximately 3,000 aging aircraft beginning about FY 2010 to sustain its planned force structure. The JSF program is designed to accomplish that goal, while significantly increasing individual aircraft capability. Capitalizing on technology advances, including electronics, materials, and manufacturing processes, the JSF is projected to combine substantial combat mission radius, high survivability against air defenses, and a substantial

payload, making it much more effective in JV 2010 and subsequent threat environment (ADR, 1998, 3-45).

The Office of the Secretary of Defense (OSD) commissioned a study in 1997 to establish a baseline on JCAS capabilities and recommend weapon system upgrades to the current inventory, focused on improving night operations. Based on CAS deficiencies identified by the joint community, post-Desert Storm reports and Combat Training Center (CTC) rotations, the OSD initiated a Joint CAS test and evaluation program for all four services. The issue of deficient night CAS capability was nominated by the Air Force for study in July 1996 and was later expanded by OSD in July 1998 to include day CAS. The JCAS Joint Test & Evaluation (JT & E) Charter encompassed three major issues:

1. What is the JCAS baseline effectiveness?
2. How do alternative CAS control procedures increase JCAS effectiveness compared to baseline?
3. How much do improvements to CAS systems and/or Tactics, Techniques, and Procedures (TTP) increase JCAS effectiveness compared to baseline? (Boudreaux, 1998, 1-2).

Joint Publication 3-09.3 identifies the unique capabilities of CAS to enhance success during the five campaign phases: prehostilities, lodgment, decisive combat, follow-through, and post-hostilities. The JCAS study focuses strictly on the decisive combat phase where CAS proves the most viable as a force multiplier. The JCAS baseline study should be published in preliminary form in late spring 1999.

If the existing CAS weapon systems fail to survive through anticipated life expectancies or advanced systems (i.e., JSF) become cost-prohibitive, emerging technologies, such as UAVs, might answer the call for a bridge to the next-generation of CAS weapon systems. What is the vision of warfare in 2010? *Joint Vision 2010* sets "the conceptual template for joint operations

and warfighting in the future, full spectrum dominance rests on the foundations of information superiority and technological innovation (National Military Strategy, 1997, 17).”

The United States Army designed Force XXI to fulfill *Joint Vision 2010* requirements. Force XXI is the process to build America’s Army for the 21<sup>st</sup> century. Force XXI seeks to leverage the power of information age technology to the advantage of the Army’s quality people and integrate information from BattleLab and Advanced Warfighting Experiments, Advanced Concept Technology Demonstrations and Functional Area Assessments. The desired result is a knowledge and capabilities-based, threats-adaptive force organized around information and information technologies (Walker and Reimer, 1998, 28). Force XXI concentrates on technically proficient warfighters armed with miniaturized technology to improve lethality and shorten the leader’s decision cycle.

The United States Air Force vision focuses on global engagement in the twenty-first century Air Force. The future battlefield requires stealth or low-observable technology, global response, information fusion and high-speed communication networks. The Air Force seeks to prepare for the JV 2010 battlefield through a series of focused battle laboratories for space, air expeditionary forces, battle management, force protection, information warfare, and UAVs.

Military forces must be flexible enough to shift rapidly and efficiently between military operations other than war (MOOTW) and major theater war (MTW). Hostile forces, terrorist groups, and nongovernmental interest groups will employ technologies capable of defeating or disrupting attainment of U.S. objectives. The four operational concepts of JV 2010--dominant maneuver, precision engagement, full-dimensional protection, and focused logistics--must be integrated in the future CAS infrastructure. Combat UAVs in the CAS role will meet the requirements of dominant maneuver and precision engagement detailed in JV 2010.

## CHAPTER 4

### UAV DOCTRINE, STRIKE STAR 2025 AND THE UCAV

So, from the sky in the aerospace medium, we will be able to converge on a multitude of targets. The impact will be the classic way you win battles—with shock and surprise.

General Ronald Fogleman, Air Force Chief of Staff (1995)

In the midst of Air Force institutional growth, what doctrine, future threat scenarios and emerging technologies exist to employ unmanned systems? UAVs are slowly becoming institutionalized within the United States Air Force, with two operational UAV squadrons at Indian River, Nevada. This chapter examines the existing Joint UAV doctrine in order to assess adaptability to embrace unmanned weapon carriers within the current doctrinal framework. The central issues assessed are UAV infrastructure and command and control system essentials. This doctrinal review evaluates the suitability of the doctrine to effectively integrate unmanned systems in combat operations. Next, the research examines the *Air Force 2025* study that explores required aerospace assets for the future battlefield. The *Air Force 2025* UAV project provides a guideline on UAV attributes, roles, and technology requirements. The UAV role will serve as a platform to evaluate the technology required to bridge the gap in current day technology and future applications. Then, the research will focus on the uninhabited combat aerial vehicle (UCAV), a possible platform to link doctrinal essentials with *Air Force 2025* study recommendations. The research concentrates on UCAV objectives, technology, and potential combat applications. Joint doctrine, *Air Force 2025* UAV study recommendations and UCAV technology will serve as the basis to evaluate the ability of unmanned systems to execute the CAS mission.

Joint Publication 3-55.1, *Joint Tactics, Techniques, and Procedures For Unmanned Aerial Vehicles*, dated 27 August 1993, serves as the overarching document for the command and control, tasking, and employment of unmanned systems. Joint Pub 3-55.1 is currently under revision to expand the doctrinal framework to include UAV roles and missions beyond the typical intelligence, surveillance, and reconnaissance (ISR) role prevalent since employment in Southeast Asia. The review and update process will allow for the growth potential of UAVs in the suppression of enemy air defense (SEAD), communication relays, navigation surrogates, and potential strike platforms.

What are the general doctrinal requirements for the UAV infrastructure? First, UAVs must meet the needs of the JFC through oriented intelligence operations to support land, air and maritime operations. Second, UAV requests and tasking flow through the JAOC. Third, UAV airspace control is exercised through the Airspace Control Authority (ACA) to facilitate safety, air defense identification and expedite the timely flow of traffic. Fourth, a highly integrated communication and control network must exist. In order to ensure the UAV system meets the operational needs of the JFC, planners must consider certain factors. table 4 details planning considerations for UAV missions.

Table 4. JP 3-55.1 UAV Mission Planning Factors

<ul style="list-style-type: none"> <li>▪ MISSION PURPOSE</li> <li>▪ ELEMENTS OF ESSENTIAL INFORMATION TO DEVELOP MISSIONS</li> <li>▪ JOINT SEAD/ELECTRONIC WARFARE</li> <li>▪ THREATS IN TARGET AREA</li> <li>▪ ROUTE AND TARGET AREA WEATHER</li> <li>▪ FRIENDLY FORCE COORDINATION</li> <li>▪ COMMUNICATION LINKS/FREQUENCIES</li> <li>▪ LAUNCH/RECOVERY TIMES AND LOCATIONS</li> <li>▪ ROUTING &amp; SYNCHRONIZATION</li> <li>▪ INTELLIGENCE ANALYSTS</li> <li>▪ SECURITY &amp; SUPPORT FOR UAV UNITS</li> </ul>
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Source: Joint Publication 3-55.1, 1993, II-15

The UAV mission planning considerations closely mirror the requirements for any aircraft system and do not present any new doctrinal imperatives totally unique to unmanned systems. Therefore, a UAV infrastructure properly manned and trained to conduct air operations would address each of these planning considerations.

Joint Publication 3-55.1 addresses some advantages and disadvantages of UAV systems which are important to capture prior to looking at future prospects for UAV employment (table 5).

Table 5. UAB System Advantages and Disadvantages

<b>ADVANTAGES</b>	<b>DISADVANTAGES</b>
Difficult to detect visually & does not present a clear radar signature	Constraints or difficulty integrating in high civil aviation traffic zones and foreign shipping
Collect combat data in real or near-real time	Environmental restrictions to flight (icing, strong winds)
Transmit to ground stations by data link 24hrs/day	Requirement for LOS between the UAV & controlling or relay station (ground, air, ship)
Interfaces with JSTARS & other intelligence sources	
Deployment requirements less than other airborne intelligence collection resources	
Interoperable between Services	
Requires little special training to use UAV information	

Source: Joint Publication 3-55.1, 1993, II-15.

The advantages column (table 5) appears to outweigh the disadvantages column for employing UAVs. The advantage of reduced detection increases the survivability of unmanned systems in medium and high threat environments. The advantages of collecting near real-time data, interfacing with intelligence sources and communicating with all Service components increases opportunities to synthesize information and fulfill JFC requirements.

The disadvantages (table 5) listed for employing UAVs are difficulties which cannot be completely answered through doctrinal changes. Technical improvements are required to deal with environmental restrictions to flight. Specifically, the Global Hawk UAV system design



incorporated structural improvements to mitigate affects of icing and strong winds. UAV integration with civil air traffic requires both a doctrinal change and technology change. The Federal Aviation Administration (FAA) serves as the lead governmental agency to set civil air traffic and federal aviation rules and doctrine. The FAA produced a draft notice on the use of UAVs in the National Airspace System (NAS). The FAA formed working groups to deal with the issues of see-and-avoid concepts, safe termination procedures in loss of communication situations, and integration into procedural manned flight rules (Kemp, 1997, 28). Once in the combat zone, UAV airspace deconfliction issues are resolved by joint doctrine. Joint Publication 3-52, *Joint Doctrine for Joint Airspace Control in the Combat Zone*, provides overall guidance. Outside the combat zone, UAV training missions are conducted predominately in military special use airspace. Currently, UAVs conducting operational missions are only allowed in friendly civilian airspace for strategic applications. Although sufficient in the short-term, the current FAA policy would prove impractical for safe passage of large packages of UAVs in the NAS.

Europe is ahead of the FAA in devising regulations on UAV use outside controlled airspace and will most likely develop policies the U.S. will adopt (Kemp, 1997, 28). The French civil aviation authority has already certified a rotary wing UAV for unrestricted flight operations in civilian airspace. Technologically, the FAA requires refined aircraft identification equipment to make unrestricted flight operations in civilian airspace a routine practice.

The LOS control issue is somewhat more problematic and requires the combination of existing technology as a stop gap and emerging technology as a longer term resolution. The UAV emerging technology section addresses the specific advances made in extended range communication and control. The integration with civil air traffic, foreign shipping and LOS control are still significant hurdles for the UAV community.

In the area of command and control, UAVs remain under the operational control of the Service component. The Service components are directed by the JFC to provide tactical support

to another component on a mission-by-mission basis. Flight control of individual UAVs remain under the UAV unit commander's control just as manned aircraft systems operate. The general TACON issues for UAV control closely mirror manned aircraft command and control issues.

Lieutenant Commander Thomas Lukaszewicz conducted research on Joint doctrine and UAV employment for the Naval War College, Department of Joint Military Operations. He identified Service component OPCON as a major shortfall in Joint UAV Doctrine. Based on competing UAV requirements and ad hoc operational control of UAV operations in Bosnia, Lieutenant Commander Lukaszewicz proposed clearer delineation of OPCON and TACON responsibilities to better detail Service component involvement (Lukaszewicz, 1996, 15). Although, overarching joint doctrine assigns OPCON and combatant command to the CINC, Lieutenant Commander Lukaszewicz assessed joint UAV doctrine inadequate on the issue of assigning and allocating UAV assets and missions while under Service component control. As a clarification to existing joint UAV doctrine, he advocated the JFC as arbitrator and decision-maker for UAV employment. He further asserts doctrine discourages multiservice component tasking of UAV assets. Considering the limited numbers and increasing demands on UAV assets, the UAV C2 and apportionment process should follow established manned aircraft structural or organizational procedures.

Despite some unclear control relationships, the researcher's review of JP 3-55.1 UAV requirements, mission considerations, and C2 requirements reveals a doctrinal framework flexible enough to embrace other UAV missions. A UAV in the CAS role can effectively operate within the Joint UAV doctrinal framework.

The *Air Force 2025* study on UAVs entitled *StrikeStar 2025* recommends a long-loiter, cost-effective, lethal UAV conducting "air occupation" over 3000nm from home base. The researcher will examine StrikeStar attributes and C2 requirements and assess compatibility as a

CAS platform. Three strategic assumptions are made regarding the year 2025 that set the stage for a lethal UAV requirement:

1. Americans will be sensitive to the loss of life and treasure in conflict.
2. The U.S. economy will force its military to be even more cost-effective.
3. Technology will give potential enemies the ability to act and react quickly (StrikeStar 2025, 1996, 22).

These assumptions are universally acceptable and feasible in today's American culture and can reasonably be expected to exist well into the future. Another important aspect expressed by the StrikeStar 2025 team identifies the rationale for developing an unmanned strike platform. The team projects a decline in the number of strike aircraft assets and pilots to one-fourth the size of 1996 numbers based on life cycle, modernization efforts, and retention. The StrikeStar 2025 team advocates maintaining a fleet of orbiting UAVs on a 30-minute response time. The StrikeStar's rapid response time to high threat areas helps to achieve information dominance, shock, surprise, and precision by remaining inside the adversary's observation-orientation-decision-action (OODA) loop.

The StrikeStar 2025 combat environment demands a stealthy platform with specific capabilities to prove viable across the spectrum of conflict from military operations other than war (MOOTW) to major theater war (MTW). Table 6 presents the factors and rationale to keep the strike UAV viable and cost effective.

Table 6. Air Force 2025 UAV Attributes

UAV REQUIREMENT	RATIONALE
Minimal sensor load	Expensive sensors on airborne and space reconnaissance vehicles feed info to UAV
Secure, redundant, communications architecture connected to command element	Multiple comm. routes; UAV normally in receive-only mode to avoid detection
Air or ground element receives fused reconnaissance	Used to direct UAV to target
Minimum 4,000lb payload	Allows for all weather, mixed weapons load
All weather directed energy weapon	Allows hundreds of engagements per sortie
Range, altitude, endurance capabilities	Limits overseas basing rights requirements (travel 3,700nm and loiter 24 hrs then return)
Cruise above 65,000 feet	Fly above weather and conventional aircraft to eliminate air traffic issues, until needed
Human interface, redundancy, reliability (man-in-the-loop)	Prevents inadvertent or unintentional use of lethal force; public accountability

Source: *StrikeStar 2025* study, 1996, 38-42.

The 2025 UAV attributes provide advantages and disadvantages in a potential close air support environment. The advantages are increased weapon payload capacity, all weather ordnance delivery, extended range and loiter, increased survivability, improved airspace deconfliction and secure, redundant communications. The disadvantages are weapon dispersion from high altitudes, increased target confirmation requirements for ground forces and greater reliance on space-based or airborne links for fused reconnaissance (clear target picture). The StrikeStar team fused the attributes of the Dark Star UAV and the Global Hawk UAV to form the StrikeStar 2025 characteristics in Table 7:

Table 7. Strike Star System Characteristics

Characteristic	Strike Star
Wingspan (ft)	105
Max Altitude (ft)	>80,000
Endurance (hrs)	>40
Radius action (nm)	3700nm 2/24 hr loiter
Max Speed (kts)	>400
Cruise Speed (kts)	400
Loiter Speed (kts)	400
Payload Weight (lbs)	4000
Max Weight (lbs)	24,000
Navigation	GPS/INS

Source: *Strike Star 2025* study, 1996, 35.

The StrikeStar system characteristics, minus payload weight (by 2000 pounds), have been demonstrated on the Global Hawk, high-altitude endurance UAV in 1998. The emerging technology in smaller, light-weight sensors combined with the Global Hawk UAV could turn the StrikeStar concept into reality by the year 2025.

The crucial link in effective employment of the StrikeStar UAV is the command and control infrastructure. Figure 1 displays the StrikeStar team's vision of the C2 infrastructure.

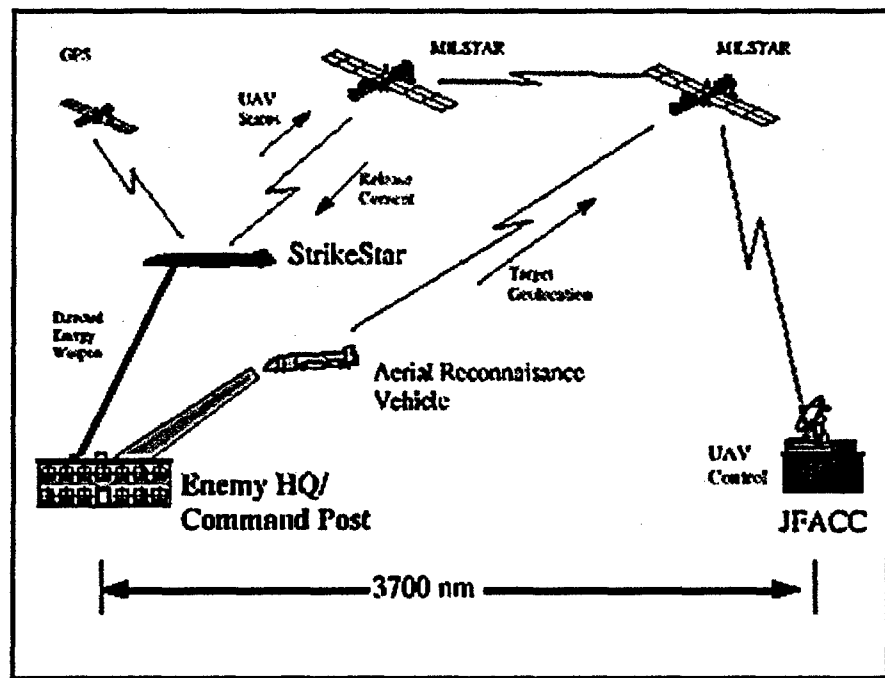


Figure 1. Strike Star C2 Infrastructure (*Strike Star 2025*, 1996, 64).

The pivotal link in the C2 infrastructure is the satellite data link for UAV control, target identification, weapons release, and fused reconnaissance. Without adequate satellite links the StrikeStar UAV cannot function under the proposed infrastructure. The DoD battlefield operational concept development program detailed in the 1998 *Annual Defense Review* (ADR) proposes research and development of a time critical targeting system for destroying theater ballistic missile transporter-erector launches. The time critical targeting system combines systems which ensure timely detection and discrimination, automatic target recognition with moving target indicator tracking and near real-time data transfer for quick lethal attack operations (ADR, 1998, 14-4).

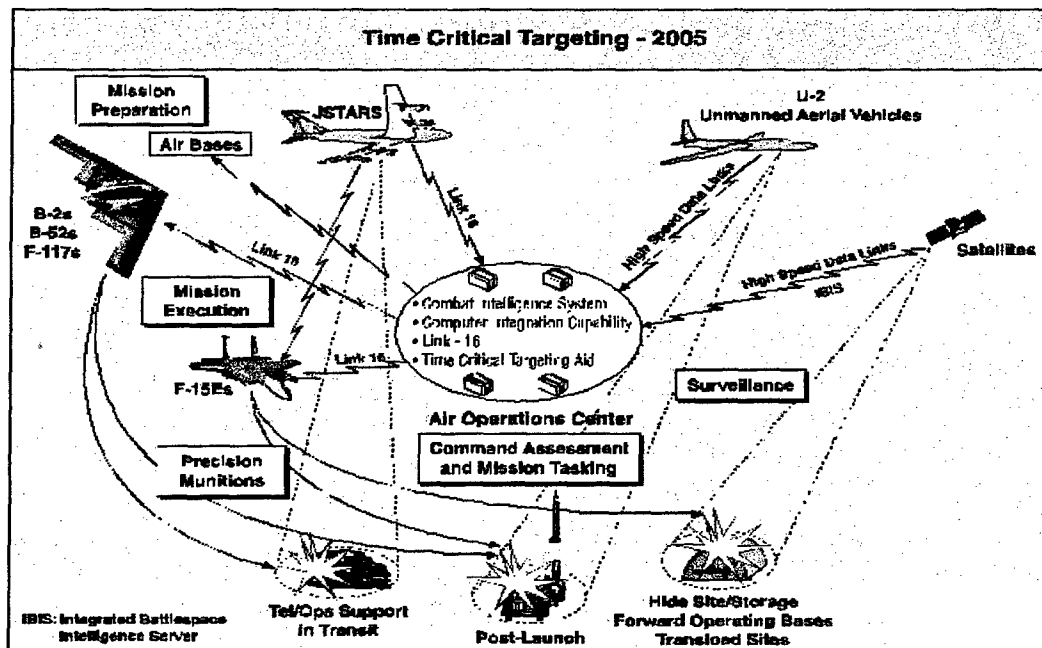


Figure 2. Time Critical Targeting System. (ADR, 1998, 14-4).

The time critical targeting system merges ISR assets, target recognition, and C2 elements to facilitate rapid tasking of strike platforms. Successful development of the time critical targeting system will construct a framework well-suited for UAV employment in a CAS role.

The *Strike Star 2025* UAV Study articulates viable UAV attributes and system characteristics. A long-loiter, lethal UAV system which builds on successes of current UAV designs could deploy in the year 2025.

The Strike Star UAV is proposed for warfare in the year 2025, but what emerging technology is available for aircraft shortfalls in fiscal year 2015? The Unmanned Combat Aerial Vehicle (UCAV), a joint Defense Advanced Research Projects Agency (DARPA)/Air Force Advanced Technology Demonstration (ATD) program is funded through fiscal year 2002 to demonstrate the feasibility of effective, affordable unmanned strike aircraft. First, the researcher will examine the Air Force Scientific Advisory Board (SAB) 1996 UAV study which set the framework for UCAV development. Next, the study will examine the UCAV system capability document and

periodicals which highlight the technology requirements and design challenges for the four potential contractors (Boeing, Lockheed Martin, Northrop Grumman and Raytheon Systems). Then, the study will examine emerging technology and UAV Battlelab demonstrations, which might accelerate the UCAV from an ATD program to a fielded system. The UCAV and emerging technology will serve as the link between doctrine and Strike Star 2025 to assess the viability of employing an unmanned aircraft in the CAS role.

Gen. Ronald Fogleman, Air Force Chief of Staff, directed the 1996 study of UAV technologies and combat operations to project new UAV mission tasks and focus research and development. The SAB study group nominated the following nine mission areas for UAV employment: counter weapons of mass destruction, theater missile defense, fixed target attack, moving target attack, jamming, suppression of enemy air defenses (SEAD), intelligence, surveillance, and reconnaissance (ISR), communications, navigation support and air to air. The SAB identified major attributes of UAVs in table 8.



Table 8. SAB Attributes of UAVs

<b>Attribute</b>	<b>Functional Impacts</b>
Endurance/Presence	<ul style="list-style-type: none"> <li>• Persistent Surveillance</li> <li>• Continuous Deterrence</li> <li>• Reduced Aircraft-per-Orbit Quantities Required</li> <li>• Reduced Crew Fatigue</li> <li>• Broad, Distributed Communications Relay</li> <li>• Self-Deployable From CONUS; Can Operate From CONUS</li> <li>• Reduced Cost of Coverage</li> </ul>
Unmanned	<ul style="list-style-type: none"> <li>• Perform High Attrition Combat Tasks</li> <li>• Carry Weapons (With Fratricidal Possibilities)</li> <li>• Operate in Contaminated Environments</li> <li>• Operate in Provocative Role, Drawing Fire</li> <li>• Potentially Simpler: Reduced Cost</li> <li>• Reduced Crew Fatigue Problem</li> <li>• Less Thorough Safety Testing Required</li> <li>• Potential Kamikaze Employment</li> <li>• Reduced Cost of Coverage</li> <li>• Less Reasoning Power Than Manned Aircraft</li> <li>• Greater Need For Command &amp; Control Tether</li> <li>• Crew-Saves (Aircraft &amp; Mission) More Difficult, Less Likely</li> </ul>
Automated	<ul style="list-style-type: none"> <li>• Simpler, Less Costly Training</li> <li>• No Crew Safety Testing</li> <li>• Control Interface Simpler Than Remotely Piloted Aircraft</li> <li>• Less Stressing to Crews</li> <li>• Reduced Cost of Coverage</li> <li>• Reduced Physical Requirements for Operators</li> <li>• Crew-Saves (Aircraft &amp; Mission) More Difficult, Less Likely</li> </ul>
Distributed & Proliferated	<ul style="list-style-type: none"> <li>• Quick Response Within Zone of Coverage</li> <li>• Behind-the-Lines Operation</li> <li>• Combined Attack (Multiple Weapons)</li> <li>• Broad Area Coverage With Multiple Sensors</li> <li>• Persistent Surveillance</li> <li>• Reduced System Vulnerability</li> </ul>
High Altitude Operation	<ul style="list-style-type: none"> <li>• Survivable</li> <li>• Performance Enhancements</li> <li>• Broad Area Coverage</li> <li>• Reduced Cost of Coverage</li> <li>• Better Viewing Angle For Enhanced Target Doppler, RCS</li> <li>• Advantageous Geometry For TBM Intercept</li> </ul>
Low Altitude Operation	<ul style="list-style-type: none"> <li>• Loss Affordable</li> <li>• Operate at Short Range (Smaller Weapons, Jammers, Radars)</li> </ul>

Source: *Report on UAV Technologies and Combat Operations* (Worch, 1996, 2-3).

The major UAV attributes and complementary functional impacts reveal the significance of more detailed R & D of unmanned systems. To further explain the possible advantages of using unmanned systems, the SAB study group describes the mission impact of five factors inherent in the lethal UAV:

Altitude. UAV operating altitudes above 65,000 ft diminishes sensor and communication line-of-sight (LOS) problems and defeats the majority of surface to air missile threats and air-to-air missiles. The communication link is more effective and the aircraft is more survivable.

Endurance. Long-range unmanned aircraft with an operating radius greater than 3,000nm reduces fleet size, saves money, allows CONUS basing and permits nearly world coverage from four OCONUS sites (Roosevelt Roads, Mildenhall, Diego Garcia and Guam).

Reliability. The failure of flight management systems, such as onboard flight control, communication links and ground station support are the major factors affecting UAV program termination. The SAB study group advocates a mean-time-between-accidental-loss of greater than 20,000 hrs to make a lethal UAV cost-effective. This loss rate translates to \$2,000 per total flight hour operating cost for a \$10M vehicle.

Storability. The SAB study group recommends warehousing most of the fleet until required for combat operations. Primary training would be conducted on simulators. Second, a small UAV fleet would be employed to keep the force mission-ready. The warehousing concept anticipates saving operations and maintenance dollars.

Aperture Accommodation. Antennas and optics apertures (diameter of the opening) work counter to stealth characteristics and make aircraft more detectable. To serve as an effective lethal UAV platform, satellite communication and ground imaging systems are crucial. Proper balance in sensor/communication apertures and vehicle design preserves the viability of the UAV to successfully perform the mission (Worch, 1996, 4-2).

These attributes are key factors for evaluating the viability of a UAV system to conduct the CAS mission. In order to merge the attributes demonstrated by the Predator, Dark Star and Global Hawk UAV systems with emerging technology in weapons and warhead technology, the SAB study group recommended UAV mission system technology demonstrations. The concept of technology demonstrations uses available technology on operational UAV systems to demonstrate a capability. The demonstrated capability, if deemed cost-effective, would enter the Advanced Technology Demonstration (ATD) process where a UAV system is designed to fulfill a specific operational task. Table 9 lists the UAV technology demonstration recommendations:

Table 9. SAB Recommended UAV Technology Demonstrations

<b>Operational Tasks</b>	<b>Mission System Technology Demonstration</b>	<b>Near-Term: (1996-2005)</b>	<b>Mid-Term: (2006-2015)</b>	<b>Far-Term: (2016-2025)</b>
Jamming & SEAD	EW UAV Cluster w/ ESM, TDOA Emitter Location, & Smart Jamming	Ä		
ISR	ISR Sensors w/Onboard Image Screening	Ä		
Fixed & Moving Target Attack	Image-Derived Precision Target Geolocation	Ä		
Communications/Nav Support	Communications Relay w/ GPS Augmentation	Ä		
CWMD	Nuclear & Chem/Bio Remote Sensing		Ä	
TMD - Ballistic	IRST & Hypervelocity Missile Fire Control for BPI		Ä	
TMD - Cruise	UAV Pulse Doppler Radar & AAM Fire Control		Ä	
Air-to-Air	Air-to-Air Targeting and Weapon Guidance for Highly Agile Platform		Ä	
Other Missions	Advanced Technology Concepts			Ä

Source: *Report on UAV Technologies and Combat Operations* (Worch, 1996, 5-6).  
(A-Advanced Technology Demonstration; IRST-IR Seeker and Kinetic Kill Thruster; BPI-Ballistic Missile Position Indicator; AAM-Air to air missile)

The near-term mission system technology demonstrations for jamming and SEAD, ISR, and communications/navigation support were demonstrated by the UAV Battlelab in 1998. Fixed and moving target attack operational tasks will be evaluated in technology demonstrations during early 1999. Once all four operational tasks are validated for UAV integration, the next step involves integrating the weapons and warheads. The SAB study group highlights some UAV-compatible weapons and warheads for the Fixed Target and Moving Target operational tasks.

Table 10. SAB Missions and Weapons Technologies

	FIXED TARGET	MOVING TARGET
WEAPON	Dispenser, LOCAAS* 3.5 in. small, modular missile	Dispenser, Homing Missile (TOW, Hellfire, Maverick) 3.5 in. small, modular missile
WARHEAD	Flying Plate Incendiary High Power Microwave	Wide Area Submunitions (CEB)

Source: *Report on UAV Technologies and Combat Operations* (Worch, 1996, 6-1).

\*Munition under development

The Low Cost Autonomous Attack System (LOCAAS) munition is small (under 100 pounds), lethal and capable of autonomous target acquisition and classification. The LOCAAS is effective against light trucks, relocatable targets, surface-to-air missile installations and heavy armor. LOCAAS employs a laser seeker which acquires and classifies a target in real time at ranges over 5 kilometers. The SAB Study Group assesses the small size of munitions combined with internal carriage and dispensing highly consistent for classical air power missions, such as interdiction close air support and SEAD (Worch, 1996, 6-2). Armed with a flexible, multiple-target weapons array, the lethal UAV is within reach for fiscal year 2015.

The Air Force Scientific Advisory Board UAV Study evaluated the full spectrum of UAV technologies and combat operations. The SAB study group recommended operational tasks

infrastructure requirements to integrate the various technologies into a coherent, cost-effective weapon system.

The UCAV system capability document envisions a cost-effective, globally deployable UAV capable of conducting SEAD and strike missions in the post 2010 timeframe. A review of the UCAV system capability document will identify the required technologies to employ the system. First, to address the cost-effective aspect of the UCAV. The stated framework for total unit cost must not exceed one-third of Joint Strike Fighter costs. Additional cost savings are expected through the stated requirement for long-term storability and wide spread use of simulators to maintain operator readiness. The rationale for storability was discussed in the SAB 1996 UAV Study section.

The UCAV system capability document concentrates on mission framework guidelines. The five major attributes discussed in the SAB 1996 UAV Study section are the prime factors for evaluating an effective UCAV system. The UCAV force package should be globally deployed within twenty-four hours of tasking using established air traffic routes. With an anticipated operational availability rate greater than 90 percent, the UCAV should execute rapid turn-around of air vehicles with responsive sortie (one takeoff and landing) generation rates. The UCAV expected sortie generation rate is three to four sustained sorties, with a surge capability of four to five sorties per day.

The UCAV design must permit carriage and delivery of a wide range of weapons as well internal fuel tanks, practice munitions, and defensive countermeasures. Safe recovery with unexpended ordnance must be demonstrated in the system design. Additional design characteristics focus on survivability and control measures such as low-observable (stealth) technology, high altitude capability and sensor/communication technology.

Once in the operational theater, the UCAV should be able to search, detect, track, identify, and prioritize multiple targets at tactically significant ranges to the accuracy required to

cue and employ weapons in adverse weather, day or night. The UCAV must be capable of manned/unmanned force mix operations and demonstrate a highly reliable identify friend or foe (IFF) capability. The requirement to integrate onboard and off-board intelligence sources for proper identification of friendly, neutral and hostile forces is vital to prevent fratricide.

The UCAV System Capability Document totally embraces the SAB 1996 UAV Study recommendations by requiring a system design versus a single air vehicle. The contractor must consider the total package from design, to training, to maintenance and integration into the existing JV2010 warfighting structure. The contractors must deliver a UCAV system which cost-effectively integrates the five major attributes of endurance, high-altitude, aperture accommodation, storability and reliability.

The USAF UAV Battlelab at Eglin Air Force Base, Florida, was created to evaluate low-cost, innovative ideas which improve the effectiveness of the USAF. The focus for the UAV Battlelab was described by Colonel Joseph D. Grasso, the commander, "not as a systems development organization, but more an impetus for operational changes using 'off-the-shelf' hardware that could benefit UAV employment (Tirpak, 1996, 74)." The UAV Battlelab bridges the gap between emerging technology and operational shortfalls. Since inception in 1997, the USAF UAV Battlelab has conducted or assessed numerous demonstrations to improve UAV integration into mainstream aerospace operations.

In December 1997, the Chief of Naval Operations sponsored the submarine's use of a UAV to support special operations sea-air-land (SEAL) forces exercising a strike against an enemy cruise missile battery (Robinson, 1997, 21). A miniature ground control station and joint deployable intelligence support system were installed in the submarine's radio room. The Predator UAV "searched the SEAL team's route to the landing site, identified a vessel at the primary site and facilitated landing at alternate site and relayed imagery of the successful strike

on the cruise missile battery (Robinson, 1997, 21).” This demonstrated the viability of subsurface control of UAVs, for over-the-horizon targeting to support cruise missile strikes, well inland.

During 1998, the USAF UAV Battlelab conducted several demonstrations. The Battlelab studied the use of adding traffic-alert collision avoidance (TCAS) avionics on large UAV airframes to permit safe flight in civilian airspace. The development of a backup TCAS system for UAVs MIGHT alleviate the complication of mixing unmanned aircraft with manned aircraft, especially in high traffic civilian airspace. Three other studies evaluated UAV employment as a laser target designator, GPS surrogate or pseudolites platform and force protection asset. These studies addressed operational requirements to enhance night attack precision, neutralize GPS jamming technology (enhance global accuracy) and serve as additional eyes for base defense.

During 1999, the UAV Battlelab will focus on SEAD missions, communication relay demonstrations and support for small scale contingencies. The UAV Battlelab approach of leveraging low-cost, off-the-shelf technologies will continue to meet the needs of the joint force while modernization efforts and research and development continues on high-altitude endurance reconnaissance UAVs and the lethalUCAV.

## CHAPTER 5

### CAS AND THE UAV

After reconnaissance, I think the next area that starts to make sense for UAVs is some sort of unmanned attack airplane. Something that can carry a load of ordnance over a distance, to go precisely attack a target. (Tirpak, *Air Force Magazine*, 1997, 70)

General Ronald R. Fogleman, Air Force Chief of Staff

Unmanned aerial vehicles, emerging miniaturized technologies, military will and fiscal constraints are slowly merging into a weapons infrastructure capable of taking the fight to the enemy through lethal means. Capabilities demonstrated through the UAV BattleLab and Advanced Technology Demonstrations of the DarkStar and Global Hawk UAVs are rapidly accelerating the usefulness of unmanned systems in military operations for the warfighting CINC. This chapter combines the CAS and UAV doctrinal requirements detailed in Chapters four and five to access the infrastructure for conducting close air support through an unmanned system. CAS and UAV doctrinal requirements lay the framework for employing manned systems. The doctrinal essentials further reveal the compatibility or incompatibility of the unmanned combat aerial vehicle (UCAV) to meet the demands of the CAS mission. Finally, the research highlights some military officers' viewpoints on the use of UAVs as a strike platform in the JV2010 environment, inferring the climate for military will to employ unmanned systems as CAS platforms.

#### Doctrinal Essentials and CAS/UAV Compatibility

The doctrinal requirements for CAS and UAVs in Joint Publications 3-09.3, *Joint Tactics, Techniques, and Procedures for CAS* and 3-55.1 *Joint Tactics, Techniques, and Procedures for UAVs* identified essential characteristics for the system architecture or infrastructure to conduct efficient operations.



Table 11. CAS and UAV Doctrinal Requirements Matrix

REQUIREMENTS	CAS	UAVs
ID of Friendly/Enemy Forces	X	X
Target Confirmation/Discrimination	X	X
Integrated C2 Network	X	X
Data Fusion	*added in upgrades	X
Interoperable Communication	X	X
Requests flow through JAOC	X	X
ACA facilitates airspace movement	X	X
Survivability (Low-observable)	*countermeasures	X
Weapon Lethality/Accuracy	X	*in design (UCAV)
Meet JFC needs (land, air, sea)	X	X

Table 11 displays essential doctrinal characteristics the researcher uses to reveal links between the CAS and UAV infrastructures. The proven, superior capabilities of UAVs in the intelligence, surveillance and reconnaissance (ISR) role make unmanned systems uniquely suited to gather and transmit real-time imagery to prevent fratricide and limit collateral damage. Harnessing the UAVs ISR capabilities with a UAV infrastructure capable of identifying friendly and enemy forces and confirming and discriminating target sets, the unmanned system can serve as a precise CAS weapon.

In order to employ a UAV in the CAS role, an integrated command and control (C2) network must be in place. The integrated C2 network would prove most effective within the framework of the existing JFACC structure. According to doctrine, UAV and CAS requests must flow through the Joint Air Operations Center (JAOC) . Both the JAOC and the Airspace Control Authority (ACA) fall under the jurisdiction of the JFACC. Operational effectiveness, eliminating redundancy and limiting staff allocation requirements supports placing UAV apportionment and allocation under the JFACC.

A responsive CAS and UAV infrastructure rely heavily on interoperable communication and data fusion. Interoperable communication facilitates the synchronization of land, maritime and SOF forces for striking target sets. Data fusion and complementary intelligence architectures

have made pushing intelligence down to the lowest possible command level a common practice for the theater CINC. UAV operations in Bosnia (EUCOM), Iraq (CENTCOM) and South Korea (PACOM) have honed the C2, communication and data fusion infrastructure to a point where emerging UAV weapons technology could be incorporated. A robust, interoperable communications system coupled with real-time imagery linked to ground commanders could facilitate target confirmation and weapons release. Unmanned systems properly equipped with the doctrinal essentials will fulfill the JFC requirements.

The final doctrinal requirements of survivability and weapon lethality and accuracy serve as a diverging point for the CAS and UAV infrastructures. The Gulf War Air Power Study (GWAPS) identified CAS platforms as the highest loss-rate due mostly to limited, onboard countermeasures against AAA (anti-aircraft artillery) and IR SAM (infrared surface to air missiles). The comparable size, composition and design of UAVs offer a survivability advantage over today's CAS platforms. Modernization efforts on existing CAS aircraft and acquisition of the Joint Strike Fighter (JSF) in FY 2010 should close the survivability gap with unmanned systems. While UAVs have the survivability advantage, CAS aircraft maintain the advantage in weapon lethality and accuracy. Miniaturized weapons and adaptable warhead technology are crucial to the fielding of UAVs in a CAS role. Completion of Advanced Technology Demonstrations (ATD) with the UCAV should determine the effectiveness of unmanned platforms to carry internal, miniaturized weapons as well as external, miniaturized missiles. Proof of reliability in the C2 infrastructure and positive control over weapons release should make fielding the UCAV in a strike or CAS role palatable.

The doctrine for close air support and unmanned aerial vehicle operations are flexible enough to allow the UAV infrastructure to operate in the CAS environment. UAV Command and Control, friendly and enemy force discrimination, interoperable communications, real-time

intelligence links and weapon accuracy must merge with existing architectures to effectively prosecute the close air support mission and meet the Joint Force Commander's needs.

The Department of Defense and the United States Air Force as institutions have invested a moderate amount (\$650 million since FY95) on UAV research and development. (UAV Annual Report 1997) Most of the service chiefs have supported UAV research, development and exploitation to enhance joint operations. In June 1994, General Gordon R. Sullivan, Army Chief of Staff said "the Army considers tactical UAVs essential to its need to synchronize forces and own the night (UAV Annual Report, 1995, 28)."

In the 1995 UAV Annual Report, the Army Chief of Staff, General Dennis J. Reimer and the Air Force Chief of Staff, General Ronald R. Fogleman advanced the research, development and acquisition of tactical and operational UAVs, respectively. General Reimer reiterated General Sullivan's position regarding the essential nature of tactical UAVs classifying "short and close range tactical UAVs as integral to the Army's digital maneuver and fire support capabilities. He further expressed that we are already behind in meeting the warfighter's needs for this critical capability and any further delay in the development of tactical UAVs will severely impact the way the Army trains and fights (UAV Annual Report, 1995, 20)." Although, Generals Sullivan and Reimer are arguing in support of the tactical UAV program, the effects of the weapon system are the ultimate goal. A lethal UAV equipped with multiple effect weapons, enhanced sensors, real-time imagery data links and interoperable communication could achieve the battlefield effects desired by the Army. As General Fogleman stated: "The Air Force will embrace UAVs and work to fully exploit their potential, on my watch. We are committed to making UAVs successful contributors to our nation's joint warfighting capability (UAV Annual Report, 1996, 36) General Fogleman kept his word and commissioned UAV studies by the Air Force Scientific Advisory Board and the Air Command & Staff College 2025 Study Groups. The studies produced a roadmap for UAV research, development and employment; the advanced

concept technology demonstrations of the DarkStar and Global Hawk UAVs; and, most recently the ATD for the UCAV.

The CINCs, although not overtly in favor of any specific weapon system embrace the demonstrated capabilities of unmanned systems. General J. J. Sheehan (USMC), CINCLANT expressed the prevalent view of most CINCs saying, "The promising initial results in deployments and previous exercises suggest UAVs will play an increasingly more important role in both land and maritime operations in the future. UAVs help close the sensor-to-shooter loop by providing the JTF and its components with the technology required to 'see' the modern battlefield (UAV Annual Report, 1995, 6)." The ability to extend the visual range of the Combatant Commander, with up-to-the minute updates enhances the decision-making process and accelerates reaction time. The CINCs exercise control over the UAV R & D process through the Joint Requirements Oversight Council (JROC). The CINCs annually prioritize the UAV programs and other technology requirements necessary to meet theater needs and fulfill national security objectives. The CINCs prioritized technologies for Joint SEAD, real-time targeting, integrated ISR and C2 infrastructures and BDA assets. Enhancements on current UAVs and design of emerging technologies, such as the UCAV are potential candidates to answer CINC capability shortfalls.

What are the officers involved in meeting the CINCs needs through UAV technologies saying about employing UAVs in a strike role? In an *Air Force Magazine* story regarding the *Robotic Air Force*, Colonel Joseph Grasso, Commander of the USAF UAV BattleLab, expressed his opinion on the UCAV. He said, "We could demo next year, dropping precision munitions off a UAV. But a lot of people must be convinced that it would be safe to put bombs in the 'hands' of robots. He expressed further, there are a lot of command and control issues to work through to give war planners confidence in robot airplanes exercising the same caution as humans about dropping ordnance (Tirpak, 1997, 73)." Colonel Grasso's intimate knowledge of the inner

workings of the UAV research, development and employment infrastructure further enhances the researcher's position that the UCAV C2 architecture must be superior. In the same *Air Force Magazine* article, General Fogleman stated that "for UCAVs to become a reality requires a surrogate brain in the airplane, one which would not come cheaply or easily (Tirpak, 1997, 74)." The man-in-the-loop technology and weapons safety architecture required for USAF acceptance of the UCAV demonstration should answer General Fogleman's prudent concern of inadvertent, accidental targeting of noncombatants.

In telephonic and electronic interviews with several Air Force officers, I attempted to gain an understanding of the climate for employing UAVs in a strike role. I exchanged e-mail and telephone calls with Lieutenant Colonel Tony Stone, a staff officer working UAV issues at Air Combat Command (ACC). He initially spoke of machines dropping weapons close to friendly troops conjuring up pictures of horror. Those images aside, Lieutenant Colonel Stone suggested that the toughest part of any unmanned airborne "weapons carrier" is C2 and positive control of weapons release/withhold parameters. He further stated that a fully autonomous 'weapons carrier' is simply out of the question, due to the USAF position that the application of combat airpower is a purely human function (Stone 1998). Lieutenant Colonel Stone is well aware of the competing interests at ACC for manned systems, like the F-22 and JSF over unmanned systems. Although ACC is involved with the UCAV in an unspecified manner, the two active Predator UAV squadrons fall under Air Combat Command control and demand some permanent investment for unmanned system integration into air operations.

In a February 1999 telephonic inquiry with the 11<sup>th</sup> Reconnaissance Squadron Operations Officer, Lieutenant Colonel Bob Monroe identified some unresolved issues which could hamper UCAV employment. He suggested the major shortfalls to a lethal, long-range UAV involved reliance on limited satellite data links for beyond LOS (line-of-sight) commanding, survivability, control for positive ID of friendly forces and authority for weapons release. Lieutenant Colonel

Monroe advocated a lethal UAV operating within LOS to counter the UCAV's major shortfall of limited satellite data links. He believed a shorter range, tactical UCAV would be harder to jam electronically, offer maximum flexibility, greatly eliminate fratricide and allow more integration with the Air and Ground Order of Battle. Additionally, Lieutenant Colonel Monroe raised some issues of tactical control in a troops in contact environment: Should the ground commander be in control or should the TACP be in control (Monroe 1999)?

Lieutenant Colonel Monroe offers some prudent issues for resolution prior to employment of the UCAV. The issue of limited satellite links for beyond LOS communication and C2 will impact all future military operations, including UAV operations. The link with space based assets is a crucial part of the UCAV infrastructure. Perhaps, UAV-based communication relay networks could serve as an alternate C2 link to enhance the UCAV's operational reliability and security. The researcher believes UCAV operations in the CAS environment should follow the same C2 protocol as manned CAS systems. Operating within the existing CAS command and control system extends UCAV positive control, enhances survivability mechanisms and most, importantly prevents fratricide. The limited support voiced for a lethal UAV in a CAS role involved strict man-in-the loop operations to prevent inadvertent weapons release and ensure doctrinal and tactical control.

Major Jim Shane, UAV integrator at the USAF UAV Battle Lab, provided great insight into the inner workings of the Battle Lab and ongoing proof of concept demonstrations during a December 1998 visit. He spoke first about the 3 D's approach to UAV employment. Major Shane suggested the UAV will be widely employed performing any mission the USAF deemed "Dull (reconnaissance for hours), Dirty (NBC environment) and Dangerous (SEAD hunter)." As a UAV advocate, Major Shane was supportive of the UCAV concept but admitted the UAV Battle Lab had no jurisdiction over UCAV development and design.

He volunteered some UCAV command and control issues raised at the Annual UAV Symposium:

1. Who controls and picks the targets?
2. Are Air Liaison Officers (ALO) the UAV operators or located in close proximity to the operator?
3. What is the dividing lines for 'eyes on,' especially in inclement weather?

Many of the issues, identified by Major Shane, have been addressed in previous discussions on UAV OPCON (operational control) and TACON (tactical control). To reiterate, UCAV C2 should comply with the existing CAS C2 infrastructure and CAS target identification criteria.

A final perspective comes from Colonel Rick Rosborg, 18<sup>th</sup> Air Support Operations Group Commander. He controls all the CONUS-based Tactical Air Control Parties (TACPs) east of the Mississippi River and serves as the USAF point of contact with CENTAF for bed-down of the Predator UAVs. As a fighter pilot, Colonel Rosborg admits he is not supportive of a totally unmanned air strike force. He believes a manned-unmanned air strike force is the sign of future air operations. Colonel Rosborg's stated position for UCAV employment involves direct positive control under the JAOC with apportionment, C2 and targeting under the auspices of the existing CAS system. His parting comments stressed "never replacing the man-in-the-loop and always operating UAVs under the command and control of airmen (Rosborg 1999)."

Since the USAF is tasked by Congress with the CAS role, a UAV performing CAS justifiably resides under the tactical control of airmen. Colonel Rosborg's point regarding the man-in-the-loop is the key to an effective combat UAV, especially in the CAS role. A totally autonomous system would not provide the fail-safes required by military standards regarding weapons release, danger close and preventing fratricide or collateral damage. Additionally, a manned-unmanned air strike force remains the best alternative for prosecuting an air campaign in the foreseeable future.

## Summary

The proposed Unmanned Combat Aerial Vehicle infrastructure proves compatible with existing joint doctrine for close air support and unmanned aerial vehicle operations. The integrated command and control network, robust data fusion, discrimination of friendly and enemy forces, interoperable communication and survivability characteristics should fulfill the CINC requirement to close the sensor-to-shooter loop. The military will to employ a lethal UAV orUCAV in a close air support role, although not racing along at lightning speed, is progressing through the Advanced Technology Demonstration process. The significant hurdles forUCAV employment involve doctrinal command and control issues and man-in-the-loop technology. Simply stating in doctrine that UAV operations will be coordinated and controlled through the Joint Air Operations Center does not make for common practice. Only time and combined effort expended by Air Force UAV commanders and operators, theater CINCs and staffs, service components and staffs and the Joint UAV research and development community will facilitate employment of theUCAV. Overall, the C2 architecture and the integration of existing and emerging technology will alleviate most of the military officers' concerns regarding the UAV in a CAS role.



## CHAPTER 6

### CONCLUSION

One of the clearest lessons to emerge from the short history of air power is that unity of development and employment is fundamental to air power effectiveness. (Vallance, 1996, 5)

Unmanned aerial vehicles served the needs of military commanders since the Germans launched V1 missiles and V2 rockets against the British in World War II. The United States fascination or interest in pilotless aircraft began in World War II in light of massive aircrew losses to the strategic bombardment campaign against Germany. Limiting pilot and aircrew losses has been the recurring theme for U.S. political and military leaders increased emphasis on unmanned aircraft. UAVs gained prominence most recently through military operations in the 1991 Gulf War. Since 1991, UAV research and development has produced the capable Pioneer, Predator, and Global Hawk systems. Advanced technology demonstrations served as more efficient design mechanisms, delivering enhanced lightweight sensors and miniaturized weapons.

Enhanced UAV technology and accelerated information technology advances combine to form an information architecture robust enough to handle unmanned aircraft in a strike role. Budgetary constraints and equipment and personnel shortfalls have refocused the DoD on fiscally conservative methods to ensure national defense and equip military forces for war. Future employment of UAVs in a strike role is possible technologically by 2010, however doctrine and military will lag while USAF leaders grapple with the proper unmanned-manned force. CAS remains a fundamental mission for the U.S. Air Force and a key to achieving tactical objectives. A brief review of historical uses of CAS reveals essential characteristics for effective employment. The essential CAS characteristics of identifying friendly and enemy forces, confirming or discriminating targets and delivering lethal, accurate weapons are employed through a comprehensive, joint doctrinal framework and a highly, integrated command and

control system. Although, CAS today is strictly the manned aircraft's domain, future battlefield architectures project unmanned attack aircraft operating in the close fight environment.

What should be the future of UCAV development? The USAF and ultimately Air Combat Command should aggressively pursue doctrine and employment guidance for combat UAVs as early as 2005 when the electronic combat UAV should complete the advanced technology demonstration phase. The UCAV for CAS should begin integration of emerging miniaturized weapon systems in 2005 and participate in aggressive field testing, first in a controlled test range environment and finally in a joint training environment, no later than 2008. This general timeline for the CAS UCAV permits two years refinement of the system architecture and a final decision for employment as an operational USAF weapon system in 2010.

Once the employment decision is made, the CAS UCAV architecture should support integration into an Air Expeditionary Force with manned aircraft systems. The Federal Aviation Administration technology shortfalls must be addressed by the USAF prior to 2008 to preclude airspace conflicts and mission delays. The most effective employment of the CAS UCAV is within the existing, proven combat aircraft architecture. The USAF must treat the CAS UCAV as just another weapon system with a different combat support package. Although, total acceptance into the ACC fold will extend well beyond 2010, the theater CINC and JFC requirements will most likely demand every available weapon capability to achieve victory and attain national objectives. The USAF and ACC must be proactive in pursuing and embracing the unmanned system's capability as a combat aircraft to retain the USAF air combat edge in future warfare.

What is one method for employing the CAS UCAV on the 2010 and subsequent battlefield? Initially, the CAS UCAV squadron would receive the alert order and prepare to launch (on order) to join the assigned Air Expeditionary Force. Once the execution order is given, the CAS UCAV deploys to the theater and operates from the designated airfield. Members

of the C2 architecture and support package would pre-deploy to the theater to bed-down and prepare the CAS UCAV for operations.

Once routine operations commence, apportionment decisions made by the JFC would be allocated by the JFACC and distributed by the JFLCC. CAS requests would be tasked appropriately to a strike package of CAS UCAVs or manned CAS assets. CAS UCAVs would fly both preplanned and immediate CAS missions based on a flexible, modularized multi-effect weapons suite. The C2 infrastructure would encompass a ground control element at the CAS UCAVs launch point, the in-place CAS C2 structure and a common ground station link (laptop) at the applicable ground commander's TACP location. The TACP, as the ground-air link, would serve as a partner with the main UCAV ground control element to ensure weapons are on target and friendly forces are clear. The CAS UCAV completes assigned tasking and egresses the area, returning to base to reconstitute weapons and fuel.

This brief look at the UCAV and other emerging technologies merely scratched the surface of employing UAVs in a strike role. Further research should focus on control of CAS UAVs at the tactical level. Additionally, further study must determine the proper manned-unmanned force mix to meet future battle field requirements, as well as doctrinal and operational considerations for employing UAVs in civil airspace and in concert with Air Expeditionary Forces. And, finally a visionary planner must deliberately assess the steps to integrate unmanned combat squadrons into the mainstream of Air Force operations. Prudent strategic planning for research, design, development and employment of UAVs will keep the U.S. military prepared to fight any conflict, any time, any place.

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## GLOSSARY

- Airborne Battlefield Command and Control Center.** A United States Air Force aircraft equipped with communications, data link, and display equipment; it may be employed as an airborne command post or a communications and intelligence relay facility (JP 1-02, 1998, 11).
- Airspace Control Authority.** The commander designated to assume overall responsibility for the operation of the airspace control system in the airspace control area (JP 1-02, 1998, 21).
- Air Support Operations Center.** An agency of a tactical air control system collocated with a corps headquarters or an appropriate land force headquarters, which coordinates and directs close air support and other tactical air support (JP 1-02, 1998, 23).
- Battle Damage Assessment.** The timely and accurate estimate of damage resulting from the application of military force, either lethal or non-lethal, against a predetermined objective (JP 1-02, 1998, 54).
- Close Air Support.** Air action by fixed- and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces (JP 1-02, 1998, 76).
- Cluster Bomb Unit.** An aircraft store composed of a dispenser and submunitions (JP 1-02, 1998, 77).
- Command and Control.** The exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission (JP 1-02, 1998, 85).
- Communications Intelligence.** The Military technical and intelligence information derived from foreign communications by other than the intended recipients (JP 1-02, 1998, 89).
- Control and Reporting Center.** A mobile command, control, and communications radar element of the US Air Force theater air control system subordinate to the air operations center. The control and reporting center possesses four Modular Control Equipment operations modules and integrates a comprehensive air picture via multiple data links from air-, sea-, and land-based sensors as well as from its surveillance and control radars. It performs decentralized command and control of joint operations by conducting threat warning, battle management, theater missile defense, weapons control, combat identification, and strategic communications (JP 1-02, 1998, 99).
- Demilitarized Zone.** A defined area in which the stationing, or concentrating of military forces, or the retention or establishment of military installations of any description, is prohibited (JP 1-02, 1998, 123).

- Electronic Intelligence.** Technical and geolocation intelligence derived from foreign non-communications electromagnetic radiation emanating from other than nuclear detonations or radioactive sources (JP 1-02, 1998, 147).
- Electro-optical.** The technology associated with those components, devices and systems which are designed to interact between the electromagnetic (optical) and the electric (electronic) state (JP 1-02, 1998, 148).
- Fire Support Coordination Line.** A line established by the appropriate land or amphibious force commander to ensure coordination of fire not under the commander's control but which may affect current tactical operations. The fire support coordination line is used to coordinate fires of air, ground, or sea weapons systems using any type of ammunition against surface targets. Supporting elements may attack targets forward of the fire support coordination line without prior coordination with the land or amphibious force commander provided the attack will not produce adverse surface effects on or to the rear of the line. Attacks against surface targets behind this line must be coordinated with the appropriate land or amphibious force commander (JP 1-02, 1998, 167).
- Forward Line of Troops.** A line which indicates the most forward positions of friendly forces in any kind of military operation at a specific time. The forward line of own troops normally identifies the forward location of covering and screening forces (JP 1-02, 1998, 175).
- Forward-Looking Infrared.** An airborne, electro-optical thermal imaging device that detects far-infrared energy, converts the energy into an electronic signal, and provides a visible image for day or night viewing (JP 1-02, 1998, 175).
- Glide Bomb.** A bomb fitted with airfoils to provide lift and which is carried and released in the direction of a target by an airplane (JP 1-02, 1998, 183).
- Joint Air Operations Center.** A jointly staffed facility established for planning, directing, and executing joint air operations in support of the joint force commander's operation or campaign objectives (JP 1-02, 1998, 231).
- Joint Forces Air Component Commander.** The joint force air component commander derives authority from the joint force commander who has the authority to exercise operational control, assign missions, direct coordination among subordinate commanders, redirect and organize forces to ensure unity of effort in the accomplishment of the overall mission (JP 1-02, 1998, 233).
- Joint Forces Commander.** A general term applied to a combatant commander, subunified commander, or joint task force commander authorized to exercise combatant command (command authority) or operational control over a joint force (JP 1-02, 1998, 233).
- Joint Publication.** Publication of joint interest prepared under the cognizance of Joint Staff directorates and applicable to the Military Departments, combatant commands, and other authorized agencies (JP 1-02, 1998, 237).

**Laser Guided Bomb.** A weapon which uses a seeker to detect laser energy reflected from a laser marked/designated target and through signal processing provides guidance commands to a control system which guides the weapon to the point from which the laser energy is being reflected (JP 1-02, 1998, 248).

**Laser Target Designator.** A device that emits a beam of laser energy which is used to mark a specific place or object (JP 1-02, 1998, 248).

**Marine Air-Ground Task Force.** A task organization of Marine forces (division, aircraft wing, and service support groups) under a single command and structured to accomplish a specific mission (JP 1-02, 1998, 264).

**Military Operations Other Than War.** Operations that encompass the use of military capabilities across the range of military operations short of war. These military actions can be applied to complement any combination of the other instruments of national power and occur before, during, and after war (JP 1-02, 1998, 277).

**Night Vision Goggles.** Intensifying device that detects visible and near-infrared energy, intensifies the energy, and provides a visible image for night viewing (JP 1-02, 1998, 300).

**Suppression of Enemy Air Defenses.** That activity which neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means (JP 1-02, 1998, 421).

**Tactical Air Control Party.** A subordinate operational component of a tactical air control system designed to provide air liaison to land forces and for the control of aircraft (JP 1-02, 1998, 426).

**Unmanned Aerial Vehicle.** A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semiballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles (JP 1-02, 1998, 459).

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